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RADIATION ACCIDENTS: MEDICAL ASPECTS OF NEUTRON AND GAMMA-RAY EXPOSURES

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HEALTH PHYSICS DIVISION

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PREFACE

The Oak Ridge National Laboratory was asked by the Division of Biology and Medicine, U. S. Atomic Energy Commission, to study methods for determining the radiation dose received by persons involved in accidental criticality excursions. A system of dosimetry for this purpose has been devised and partially implemented at various AEC contractor sites in the United States. One objective of Part A of this report is to serve as an information manual for those persons responsible for implementing this system. A review and re-evaluation of the dosimetry of previous accidents is also included in the introduction of Part A.

Part B of the report deals with a review and analysis of the medical data obtained from previous criticality accidents. It includes a method of defining human radiation injury and gives recommendations for clinical and laboratory observations for future cases. Parts A and B together form a complete analysis of dosimetric and medical information pertinent to acute exposures of humans to mixed radiations, and thus provide a basis for the correlation of biological effects on man with radiation dose.

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1. REVIEW OF PREVIOUS ACCIDENT MEDICAL DATA

1.1 Introduction

Present knowledge of the effects of known doses of various radiations on normal humans is obtained indirectly from controlled experiments with mice, rats, rabbits, and monkeys in the radiobiological laboratory, from analyses of findings in therapeutically irradiated sick humans, and from retrospective studies of atomic bomb survivors and accidental human radiation exposure victims.

Several drawbacks are evident in these sources of information. Because of the variations in radiosensitivity of different tissues in different species, the controlled laboratory studies are not readily extrapolated to man. The biological response of recipients of therapeutic irradiation are not necessarily those of normal humans. In accidental exposures of normal humans, detailed precise measurements of dose and uniform selection of test parameters and procedures have not always been possible. Because of these drawbacks, it is deemed essential that certain medical guidelines be established for the management of cases of radiation overexposure, not only to facilitate the therapy of accidental clinical radiation injury in a patient but also to expedite the accumulation of more useful data concerning such injury, as a basis for further improvement in its diagnosis and therapy.

To make maximum use of past experiences with radiation accidents in developing guidelines for their future clinical management, all

presently available data concerning human exposure in criticality accidents have been reviewed.[1-15] Only information obtained from previous healthy patients whose radiation exposure was acute, external, penetrating, and generalized has been considered. The clinical syndromes resulting from various protracted, internal, superficial, and localized exposures are too varied for the present purposes.

There have been seven major nuclear accidents involving significant overexposures of personnel to ionizing radiation since the rapid development of the field of nuclear technology began 20 years ago. The chronology of these accidents is given in Table I. The sequence of events and the conditions of exposure which are pertinent to an understanding of the physical dosimetry were described in Part A of this report,[16] as well as a re-evaluation of the doses estimated for the 32 individuals involved in these accidents. For the convenience of readers who do not have immediate access to Part A, the exposure data are summarized in Table II; the doses are presented as recorded in the original literature and also as recalculated according to the methods described in Part A.

To make clear the sequence in which the subject matter of this report is presented, the steps are summarized here. Present information about clinical radiation effects provides the basis for establishment of an arbitrary but useful classification of five categories of injury in increasing order of severity. A hypothetical case history of a typical patient in each of the five groups is described. The 32 patients involved in criticality accidents are classified,

Table I

Chronology of Radiation Accidents

Accident	Date	Type
Los Alamos I	Aug. 21, 1945	Criticality (Exp. assembly)
Los Alamos II	May 21, 1946	Criticality (Exp. assembly)
Argonne	June 2, 1952	Criticality (Reactor)
U.S.S.R.	1953 - 1955 ?	Criticality (Reactor)
Oak Ridge	June 16, 1958	Criticality (Processing)
Yugoslavia	Oct. 15, 1958	Criticality (Reactor)
Los Alamos III	Dec. 30, 1958	Criticality (Processing)

Table II

Summary of Exposure Data

Accident	Number Patients	Patient Code*		Reported Total Body Dose			Calculated Total Body Dose		Calculated*a Total Rad Dose
		R	L	Neutron	Gamma	Total	Neutron	Gamma	
LASL - I	2	LA1	1	480 rem*b	110 rem	590 rem	297 rad	?	297 +
		LA2	2	31	0.14	31	18.2	2	20.2
LASL - II	8*c	LA3	3	1930 rem*b	114 rem	2044 rem	1230	120	1350
		LA4	4	390	26.4	416	220	22	242
		LA6	6	186	10.7	196	120	12	142
		LA7	7	140	8.7	148	50	5	55
		LA8	8	55	4.37	59	33	3	36
		LA9	9	42	2.72	44	25	2.5?	27.5
		LA10	10	33	2.41	35	20	2	22
Argonne	4	A1	1	14.2 rep	145 rep	189 rem*d	14.2	145	159
		A2	2	9.6	116	146	9.6	116	126
		A3	3	5.5	55	71	5.5	55	60.5
		A4	4	0.8	10	12	0.8	10	10.8

*First column (R) designates code used in this report. Second column (L) designates pctient code that appears in the literature.

*aRecalculation based on serum Na^{24} data.

*bThe rem values expressed in the LASL-I and II cases are based on an assumed RBE value of 5 for fast neutrons with an approximate depth dose penetration equivalent to that of 80 KV unfiltered X-rays.

*cData on patient LA5 not available.

*dBased on an assumed RBE value of 3 for fast neutrons.

Table II (continued)

Accident	Number Patients	Patient Code* R	Patient Code* L	Reported Total Body Dose Neutron	Reported Total Body Dose Gamma	Reported Total Body Dose Total	Calculated Total Body Dose Neutron	Calculated Total Body Dose Gamma	Calculated*a Total Rad Dose
USSR	2	R1	Kh	?	?	450	?	?	450*e
		R2	M	?	?	300	?	?	300
Oak Ridge	8	OR1	A	96 rad	269 rad	365 rad	96	269	365
		OR2	C	89	250	339	89	250	339
		OR3	D	86	241	327	86	241	327
		OR4	B	71	199	270	71	199	270
		OR5	E			236	62	174	236
		OR6	F	18	50.5	68.5	18	50.5	68.5
		OR7	G	18	50.5	68.5	18	50.5	68.5
		OR8	H	6	16.8	22.8	6	16.8	22.8
				Physical Estimate Total*f		Clinical Estimate Total			
Yugoslavia	6	Y1	V	840 rem		1000 – 1200 rem	320	320	640
		Y2	D	1024		700 – 1000	250	250	500*g
		Y3	M	856		700 – 1000	290	290	580
		Y4	G	920		700 – 1000	300	300	600
		Y5	H	696		600 – 800	210	210	420
		Y6	B	408		300 – 500	175	175	350
LASL - III	2	LA11	CWK			12000 rem*h	2300	6900	9200
		LA12	RSD			135			

*e Expressed in original report in r only with no mention of neutron or gamma components. Total rad doses are assumptions only.

*f Total rem dose. Neutron and gamma dose estimates not specified in original report.

*g Female patient whose weight is not available in the literature and might be considerably less than 70 KG standard man, the value used in calculating this dose. (See Table V, ORNL-2748, Part A.)

*h Estimate ±50 per cent.

each in accordance with his clinical course. The clinical laboratory findings associated with each clinical injury group are then analyzed. The predictive value of certain early laboratory test deviations as an indicator of the extent of clinical injury, and of the severity of the course to be anticipated, is demonstrated. Recommendations for diagnostic procedures in radiation injury as well as its therapeutic management are made on the basis of past experience. The relationships between clinical and laboratory evidences of injury, and the exposure dose which produced them, are analyzed.

1.2 Clinical Manifestations of Radiation Injury

The clinical characteristics of the acute radiation syndrome in man have been compiled and reviewed by many authors, including a recent summary by Gerstner.[17,18] Although variations in radiation exposure, in the health of the recipients, and in the feasibility of valid, controlled clinical observations all serve to confuse the outlines of a clear-cut symptom complex, certain landmarks emerge.

When man is exposed to a single whole-body dose of ionizing radiation, he exhibits certain clinical signs, symptoms, and laboratory findings which are collectively termed the radiation syndrome. The frequency and severity of occurrence of these manifestations are roughly related to the dose received and to the sensitivity of the

individual patient. Exposures to less than 100 rads* rarely result in clinical symptomatology; hence for our present purposes the radiation syndrome may be thought of as those clinical findings associated with total-body doses of radiation greater than 100 rads.

The typical chronologic sequence of events following a large whole-body radiation exposure can be divided into four clinical stages: the initial or prodromal stage, the latent stage, the manifest illness stage, and the recovery stage. The prodromal clinical findings include anorexia, nausea, vomiting, extreme sweating, fatigue, and prostration. These changes remit in the latent period which begins about two days later. After about two to three weeks of well-being, a number of developments begin within a short time of one another. These may include fever, overt or occult infections, scalp hyperesthesia and epilation, purpura and hemorrhage, diarrhea, ileus, cardiovascular collapse, severe lethargy, and changes in sensorium. By about the end of the sixth week after exposure the situation has usually been resolved and clinical improvement of the surviving patients is rapid, although fatigue may continue for some time.

1.2.1 Dose-Response Relationships

About 15% of patients exposed to a dose of 100 rads may be

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*The dose to a given individual is specified in terms of the absorbed dose (in rads) which would have been received by a small mass of soft tissue located in air at the position of the individual. It is realized that correlations of biological data with a single dose reading will be far from perfect unless other physical conditions of exposure are specified.

expected to show some of the signs and symptoms of the radiation syndrome. The frequency increases sharply up to the level of approximately 200 rads, at which level most of those exposed would be expected to exhibit some clinical symptomatology.

The occurrence of fatalities has been considered generally to begin at about 200 rads, increasing to 50% at about 450 to 500 rads. The findings of this survey of radiation accidents do not substantiate these estimates, probably as a result of therapeutic intervention. Death did not occur in any of these treated patients with known doses less than 500 rads. The LD_{50} is impossible to estimate accurately on the basis of the small amount of such data accumulated thus far. A fatal outcome appears likely at a dose level much above 800 rads.

It is evident that the foregoing generalizations will be influenced by the mixture of various radiations which comprise the exposure dose. However, since there are insufficient data concerning the normal human on which to base a definite statement of the relative biologic effectiveness of any given radiation, it has not seemed wise to be more precise about these dose-response relationships.

1.2.2 Radiation Injury Groups

In spite of the implication in the foregoing paragraph and in the radiobiological literature that there is a useful relationship between magnitude of dose and severity of clinical sequelae, it is considered essential to approach the problem of individual patient management from a different standpoint. This approach is necessitated in part by the

difficulty in obtaining quick and accurate dose estimates in accident situations. In addition, even if complete dosimetric information were available, the biological response of one individual to a known dose would still differ from that of his confrere exposed under identical physical circumstances. It has, therefore, been deemed useful in the management of radiation accidents arbitrarily to divide patients showing various symptoms and signs of the acute radiation syndrome into five different "radiation injury" groups.

The five radiation injury groups are defined in terms of present recognition and understanding of certain definitive clinical occurrences which have appeared in normal persons accidentally exposed to external, penetrating, whole body radiation overdosage. Briefly, the pertinent characteristics of each group may be summarized as follows:

Group I: Most of these patients are asymptomatic; a few may have minimal prodromal symptoms.

Group II: These patients develop the acute radiation syndrome in a mild form. After transient prodromal nausea and vomiting, laboratory evidence and mild clinical manifestations of hematopoietic derangement dominate the picture.

Group III: A serious course occurs in these patients. Complications of hematological malfunction are severe and some evidence of gastrointestinal damage may also be present.

Group IV: An accelerated version of the acute radiation syndrome occurs. Complications of gastrointestinal injury dominate the clinical picture. The severity of hematopoietic disturbances are related to the

length of survival time following exposure.

Group V: A fulminating course with marked central nervous system impairment occurs in this group.

1.2.3 Hypothetical Clinical Case Illustrations

In order to establish basic points of reference and to provide a better appreciation of the relevant clinical characteristics and laboratory findings, a hypothetical case report containing the expected findings for a patient in each injury group will be presented. For the purpose of illustrating all of the possible characteristic phenomena, each case will be portrayed as having experienced all or most of these findings. It must be borne in mind, however, that the radiation syndrome is similar to any other clinical entity in that it is unusual for any individual case to show all of the "textbook" findings.

Group I: Hypothetical Patient 1, a 26-year-old male technician, was exposed to a total body dose of 14 rads of fast neutrons and 39 rads of prompt gamma radiation. This exposure was experienced as the result of not employing certain safety features while performing an experiment with a low-power reactor.

When first seen by the facility physician in the dispensary, ten minutes after the accident, the patient exhibited no clinical symptoms other than a moderate tachycardia and moist palms. Blood was immediately drawn for base-line blood counts and for Na^{24} activation measurements. Bed rest in the dispensary was advised, pending the report of the first estimations of the magnitude of the exposure.

The patient became increasingly restless and apprehensive over the next two hours; since no reasonably accurate dose estimates were at that time available, it was thought advisable to hospitalize the patient.

The initial blood data, which included hematocrit, total leukocyte, total lymphocyte, total neutrophil and platelet counts, and differential formula, were normal. One hour later, blood specimens were obtained for repeat counts, as well as base-line blood chemistry determinations. The latter were all within the normal range, and there was essentially no change in the counts. The patient's apprehension continued until four hours after hospitalization, at which time it had been definitely determined that his dose was less than 100 rads. The patient was informed of this estimate and appraised of the favorable clinical prognosis. His restlessness, tachycardia, and vasomotor symptoms disappeared almost immediately, and he was discharged from the hospital the next day.

He was observed in the outpatient department for the next month, during which time he was completely asymptomatic and showed no alterations in his laboratory findings. He then returned to work in a non-exposure area. Thereafter, he was observed at increasing intervals. At no time were there any clinical or laboratory manifestations (see Fig. 1) that could be attributed to his radiation exposure. No abnormalities were noted in the bone marrow studies.

Group II: Hypothetical Patient 2, a 46-year-old male laborer, was exposed to 90 rads of fast neutrons and 240 rads of gamma rays in a

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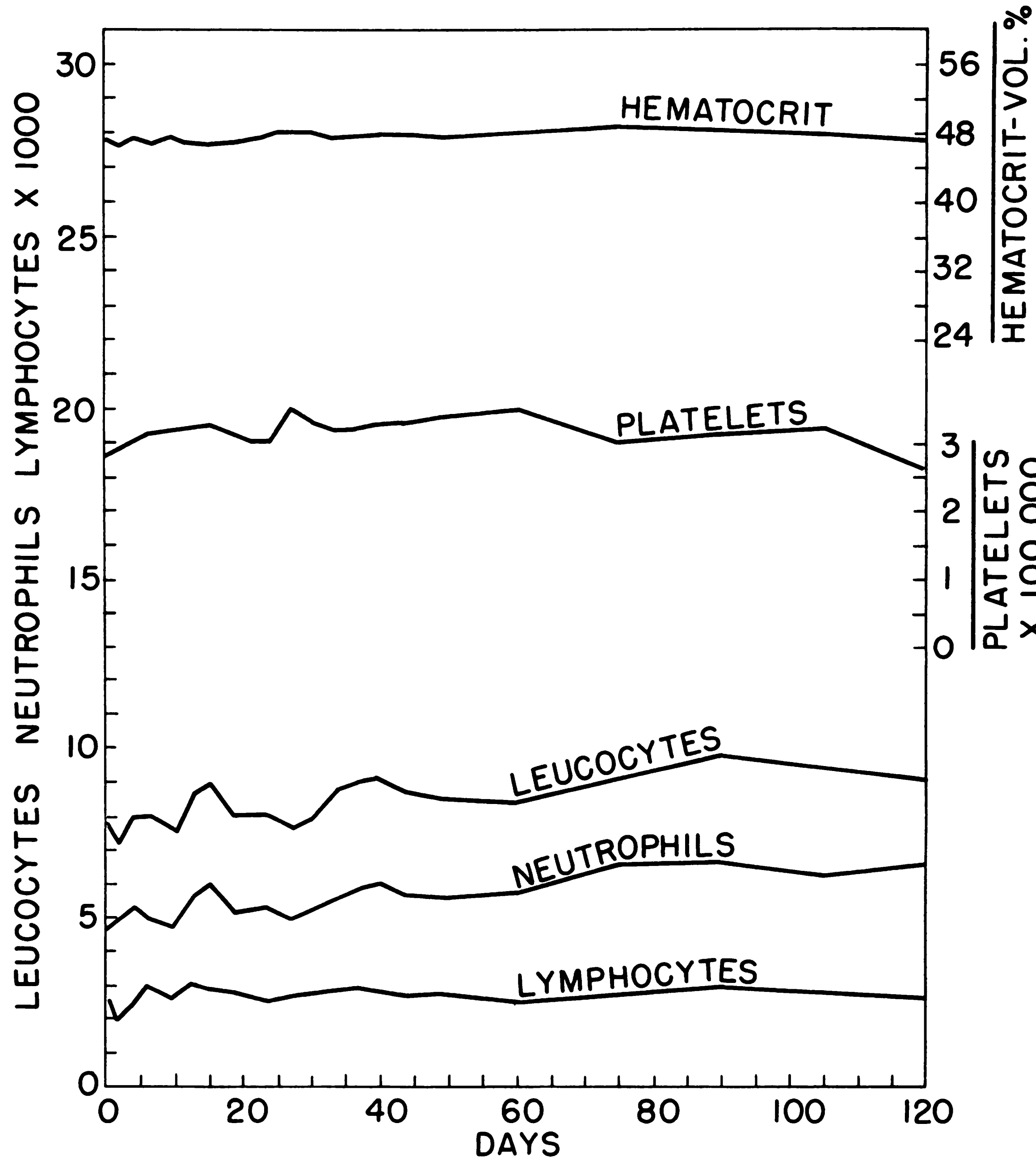

FIG. 1
BLOOD COUNTS-HYPOTHETICAL PATIENT 1

criticality type of accident at a production facility. He was hospitalized almost immediately but at the time of admission felt perfectly well. The admission physical examination and laboratory findings were all within normal limits. About two hours later, he began to experience rather persistent nausea and vomited five times within the next 24 hours.

During the next four and one-half days he exhibited no abnormal symptoms other than weakness and fatigue. His appetite remained hearty, and there were no gastrointestinal symptoms. An uneventful clinical course, except for persistence of the weakness and fatigue, was observed until Day 16 when the patient stated that his scalp was tender to the touch, especially over the occipital and right parietal regions. These were the areas most frequently in contact with his pillow. Very little further attention was given to this symptom until Day 18 when it was noted that frank epilation was beginning over these areas. The epilation continued, involving not only patchy areas of the scalp, but the hair on the chest, thighs, and legs as well. His epilation stopped on Day 29.

On Day 18 the patient complained of a severe sore throat. He had a temperature of 100.2° F accompanied by a proportionate tachycardia. Physical examination revealed an acute follicular tonsillitis with accompanying cervical adenopathy. It should be noted from Fig. 2 that there was no leukocyte response to this infection. The erythrocyte sedimentation rate increased to 32 mm. This rise preceded the clinical infection by 24 hours. Throat cultures were made and the patient was

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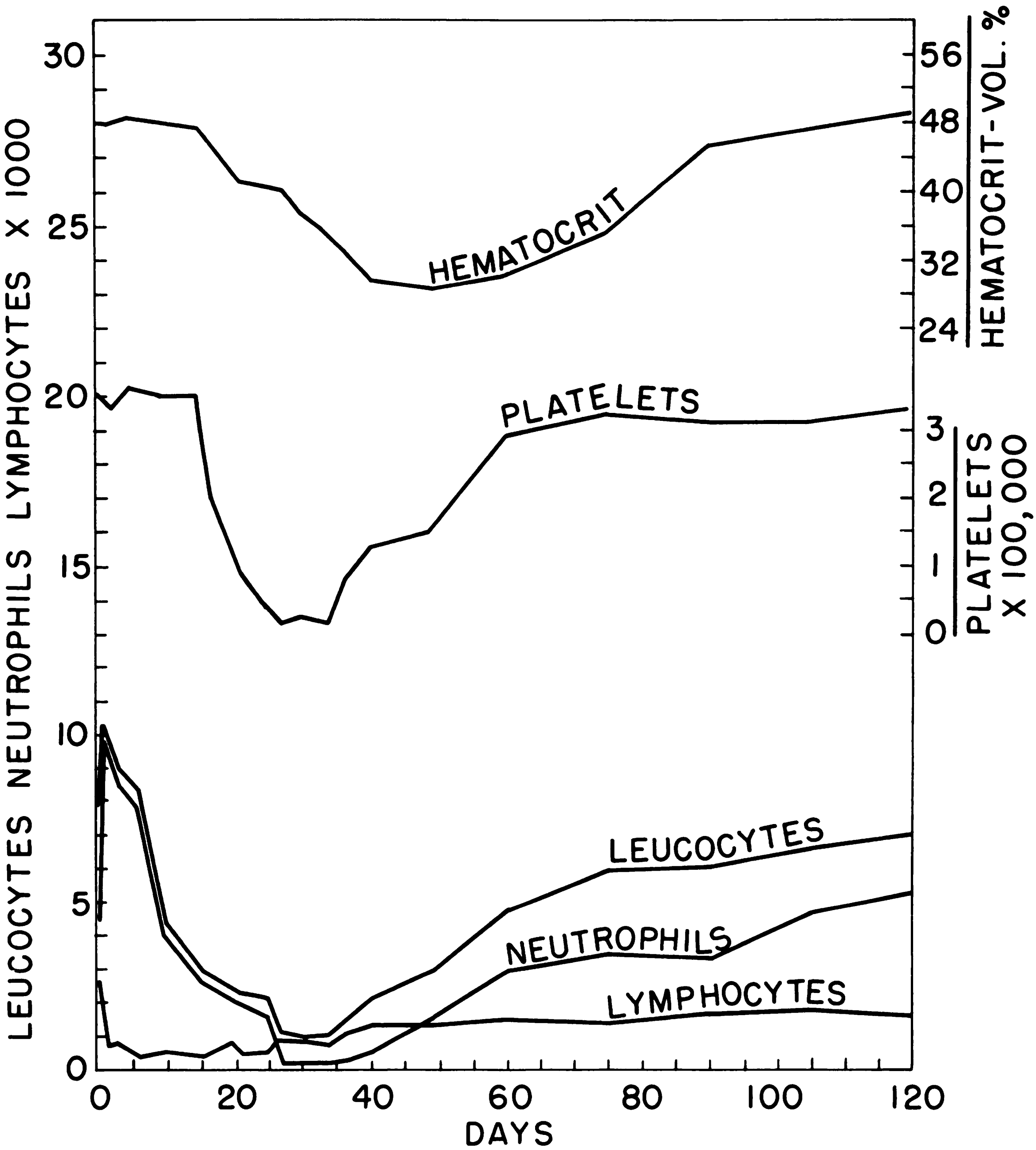

FIG. 2
BLOOD COUNTS- HYPOTHETICAL PATIENT 2

immediately started on crystalline procaine penicillin in 600,000 unit doses, intramuscularly, every six hours. There was a temperature spike in the afternoon to 104.6° F. This was preceded by a rigorous chill lasting approximately 20 minutes. The patient's throat became so sore that he was unable to swallow even sips of water. His fever was reduced with sponge baths and large doses of acetylsalicylic acid (aspirin) per rectum. Two liters of 5% dextrose in saline were administered intravenously through the afternoon and evening. There were two more episodes of chills and hyperpyrexia during the next 12 hours. It then became evident that the patient had an early peritonsillar abscess.

The growth from the throat culture was identified as an alpha-hemolytic Streptococcus, and tube sensitivity studies revealed a high sensitivity of the organism to tetracycline and a relative resistance to penicillin. He was then started on a continuous slow intravenous infusion of 1 gram of tetracycline in saline, over a 24-hour period. The tetracycline was continued by intramuscular injections of 100 mg every six hours. During the night of the 20th day the abscess drained spontaneously and the patient was afebrile on the following morning. He tolerated a liquid diet in sufficient amounts to maintain a satisfactory intake without the use of parenteral fluids. By Day 23, there was complete clinical recovery and the antibiotic therapy was discontinued.

On Day 15 the platelet count began a progressive fall to a level of only 20,000 on Day 26. It remained at essentially that level until Day 30, on which a stepwise recovery began and was complete by Day 57.

Parelleling the thrombocytopenia in its general pattern of development, there was a progressive fall in the leukocyte count, reaching a level of 850 on Day 27. The absolute neutrophil count decreased to a level of 275 on Day 27. A moderate reduction in the hematocrit also paralleled the other cytopenias.

Purpura appeared first on the lower extremities on Day 25 and became generalized by Day 30. On Days 27 and 28 the patient noted that his gums bled when he brushed his teeth. Microscopic hematuria was also noted on Day 28. There was no other evidence of hemorrhage. During this period there was marked hypocellularity of the bone marrow. Hematological findings are presented graphically in Fig. 2.

During the first 45 days the patient lost 14 pounds. The clinical course from then on was uneventful. There was a complete clearing of his purpura, and a stepwise return to normal levels of all of the components of his hemogram by Day 60. It is interesting to note, however, that his sedimentation rate remained elevated for eight months. There was complete restoration of hair growth by the end of the third post-exposure month. The patient's weakness and fatigue gradually diminished and he returned to light work in a non-radiation area five months after the accident. Periodic follow-up over the next three years failed to reveal any significant clinical or laboratory abnormalities, except for the persistent elevation of the sedimentation rate for eight months.

Group III: Hypothetical Patient 3, a 37-year-old male worker, received an estimated total body dose of 182 rads of fast neutrons and

536 rads of prompt gamma radiation in a criticality type of reactor accident.

He experienced no immediate reactions to this exposure; however, with a few minutes after his arrival at the hospital admitting room approximately 45 minutes after the accident, he became nauseated and experienced violent retching and vomiting, perspired profusely, and felt extremely weak. Initial physical examination failed to reveal any significant abnormalities other than a moderate tachycardia, sweating, and a slightly increased respiratory rate. The rectal temperature was normal, as was the blood pressure. Blood and urine samples were obtained immediately for complete blood counts and baseline biochemical values, urinalysis, and Na^{24} measurement.. The initial blood counts and urinalysis were within normal limits.

During the next 12 hours of his hospitalization, the patient continued to have nausea and vomiting. The sweating subsided, but the weakness persisted. A second blood count, made on the 12th hour, revealed a normal hematocrit and a normal platelet count. The total leukocyte count was elevated to approximately 13,000, almost all of which were neutrophils. The lymphocyte count had fallen to 800. A temperature elevation to 100° F was noted.

A mild generalized erythema was noted toward the end of Day 1. The patient also complained of vague sensations of numbness of the upper extremities. The initial symptoms of anorexia, nausea, vomiting, weakness, erythema, and low-grade fever persisted.

There was a somewhat abrupt remission of these initial symptoms

toward the end of Day 4. His appetite returned and he was essentially asymptomatic for the next nine days. The weakness, low-grade fever, and excessive sweating, however, persisted throughout this period. On Day 14 there was a sudden temperature elevation to 103° F. Physical examination revealed an acute pharyngitis accompanied by a diffuse hyperemia of the gums and buccal mucosa. Anorexia returned with the onset of this infection. A throat culture was made and antibiotic therapy was immediately initiated. He was given intramuscular doses of 600,000 units of penicillin and 0.5 gram of streptomycin every six hours. There was a progressive temperature rise over the next 18 hours, reaching a level of 104.5° F. Early ulceration was noted in the pharynx. The hyperemia of the gums became marked. There was slight loosening of the teeth. Tube antibiotic sensitivity studies of the throat culture material revealed the pathogen to be most sensitive to tetracycline, which was immediately administered by continuous intravenous drip. A total of 1 gram was given by this method over the next 24 hours. The penicillin and streptomycin were also continued. The temperature dropped precipitously to its previous level of approximately 100° F on Day 17. The tetracycline was then administered orally in 250-mg doses every six hours. Elevation of the sedimentation rate, first noted on Day 12, decreased slightly at this time.

At the same time, Day 17, beginning epilation of the scalp was noted. The patient experienced pain and bleeding of the gums when brushing his teeth. From this time on, until death on Day 29, all stool examinations revealed occult blood. Purpura of the oral mucosa

and skin of the trunk was first noted on Day 19. This became generalized, and during the terminal stages of the illness multiple large ecchymotic areas of the skin were present.

Bone marrow biopsy revealed almost complete accellularity, which was reflected in the peripheral counts by a profound pancytopenia. Figure 3 provides a graphic illustration of all blood counts. By Day 23 the patient's general condition had progressively deteriorated to the point that he was prostrate with profound weakness, lethargy, and intermittent disorientation. The total urinary output was reduced to less than 400 cc per 24 hours. This oliguria persisted until death. Fresh whole blood and platelet transfusions were administered over the next four days.

Diarrhea, accompanied by abdominal pain and cramps, began on Day 25 and increased in severity until Day 28, at which time massive hemorrhage from the lower gastrointestinal track ensued. There was also continuous oozing of blood from the gums and one episode of hematemesis. Microscopic hematuria was also observed.

There was almost complete epilation of all of the hair of the body by this time. Early on Day 29 further severe bleeding from the lower gastrointestinal track began. The patient went into profound shock, became comatose, and in spite of vigorous transfusion therapy, died during the latter part of Day 29.

Group IV: Hypothetical Patient 4 was a 31-year-old male scientist who received a total body exposure to fast neutrons and gamma rays in a criticality reactor accident. It was estimated that his exposure

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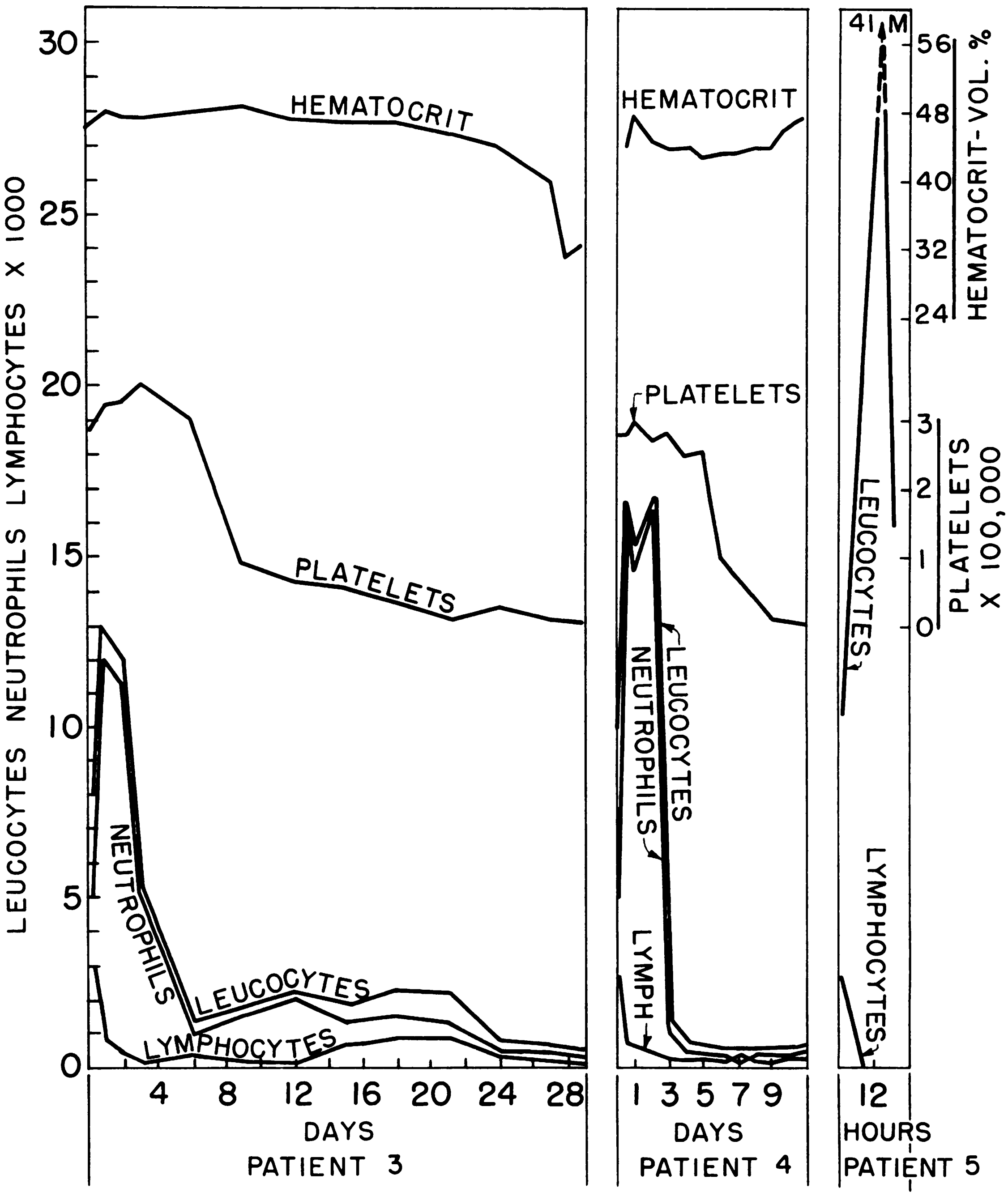

FIG. 3
BLOOD COUNTS
HYPOTHETICAL PATIENTS 3, 4, AND 5

resulted in a dose of 124 rads of fast neutrons and 830 rads of gamma rays. He immediately ran from the reactor building and was taken to the laboratory dispensary. He experienced nausea, vomiting, and retching 30 minutes after the exposure. He was hospitalized immediately. The nausea and vomiting increased in severity and frequency during the next four hours. During the third hour he experienced severe intermittent abdominal cramps followed by two watery bowel movements within a period of 20 minutes. He was weak and prostrate, but there was progressive improvement and by the 16th hour he had entered the latent phase of relative clinical well-being. He had a low-grade fever during the first 24 hours. On Day 1 there was an initial leukocytosis, almost all of which was due to an increase in neutrophils as his absolute lymphocyte count fell to 600. His leukocytosis persisted. The lymphopenia was progressive, reaching a level of 250 on Day 3. Throughout the remainder of his illness, the absolute lymphocyte count never rose above this level.

Except for a continuation of his fatigue and a temperature elevation to 100.5° F on Day 2, he was asymptomatic for the next five days. The low-grade fever persisted until Day 7.

About noon on Day 7 there was a recurrence of his nausea, vomiting, and watery diarrhea. This was accompanied by a rise in temperature to 103.2° F and a corresponding elevation in the pulse rate. Almost simultaneous with the onset of these clinical symptoms, there was a precipitous fall in the cellular elements of his peripheral blood. The total leukocyte count decreased to 1200 with a corresponding fall in

the neutrophils. The platelet count decreased from its previous normal levels to 120,000. Hematologic results are shown in Fig. 3.

The nausea and vomiting became increasingly severe, and early on Day 8 nasal gastric suction was established. There was also an increase in the severity of the diarrhea. Parenteral administration of fluids and electrolytes as well as whole blood was started, and he was placed on intramuscular penicillin and streptomycin. His temperature reached a high of 103.8° F and the blood count showed 300 leukocytes and 80,000 platelets. There was hypocellularity of the bone marrow. On Day 9 his condition was essentially unchanged.

On the 10th day, the frequency of the diarrhea increased and the watery stools became bloody. His temperature rose to 104° F and his pulse was rapid and weak. Extreme prostration ensued; he was cyanotic, and his respirations were shallow and rapid. Tetracycline was given intravenously, and he was placed in an oxygen tent. In spite of whole blood transfusions, the shock became more profound. For a few hours the circulatory collapse was successfully overcome with intravenous methoxamine HCl (Vasoxyl); however, early on Day 11 the temperature rose to 105.8° F, the shock became profound, and he died.

Group V: Hypothetical Patient 5, a 37-year-old production specialist, received an estimated total body exposure to 2000 rads of fast neutrons and 5000 rads of gamma rays. By a complex series of technical errors, a large volume of enriched uranium in a liquid form was allowed to become supercritical.

The patient stated that he immediately felt a burning sensation

over his entire body. He was able to stagger out of the building and attempted to reach a vehicle parked on the road. A maintenance man working across the road stated that he staggered aimlessly about like a drunken man for a minute or so and then collapsed on the ground. He began to retch violently within eight minutes after the exposure. He attempted to walk to the ambulance but was markedly ataxic and confused.

On admission to the hospital, 20 minutes after exposure, the patient was vomiting and had an explosive involuntary watery bowel movement. He was cyanotic and in acute respiratory distress. A generalized erythema was noted, and he was in clinical shock as evidenced by a blood pressure of 70/50. Vigorous therapy with whole blood transfusions was employed but failed to combat the clinical shock. Intravenous methoxamine Hcl (Vasoxyl) was begun during the fourth hour. The response to this therapy was insufficient to raise the patient's blood pressure out of the range of clinical shock. The vomiting and confusion persisted. The sensorium remained clouded. On the tenth hour, 90 cc of urine was obtained by catheterization, indicating that there was an almost complete anuria from the onset. By the 16th hour, prostration was marked. The patient became progressively more disoriented, and twitching of various muscles was noted. He became comatose in the 21st hour, convulsed, and died a few minutes later.

The blood counts made during the first hour were normal in every respect. Blood taken hourly for counts revealed a progressive increase in the leukocyte count to a level of 41,000 in the 16th hour followed by a steady decrease to the level of 16,000 just prior to death. By

the third hour the lymphocyte count had decreased to 950, and by the seventh hour there was a complete disappearance of lymphocytes from the peripheral blood. The findings of the bone marrow biopsy made during the early hours were not remarkable. Hematological data are presented graphically in Fig. 3.

Only 180 cc of urine was obtained from the time of the initial catheterization until death. Consistent with this oliguria, there was a steady rise in the NPN and BUN levels reaching 82 and 19 mg %, respectively.

1.3 Analysis of Accident Cases

Utilizing the available data concerning the radiation accident cases resulting from known criticality episodes it was possible to classify each case according to the criteria presented in Section 1.2.2. Table III lists the actual cases classified by radiation injury groups.

1.3.1 Clinical Signs and Symptoms

All reported clinical signs and symptoms are listed in the headings of Figs. 4 and 5 as well as those of Tables IV and V. For the sake of clarity these phenomena have been divided into those occurring during the initial stage of illness and those which occur after the subsequent latent period in the stage of manifest illness. Their occurrence among the members of each of the five injury groups is given for the initial stage in Fig. 4 and for the stage of manifest illness in Fig. 5.

Table III

Patients Classified by Clinical Radiation Injury Groups

Group	No. Patients	Patients by Code				
I	14	LA2	A1		OR6	
		LA6	A2		OR7	
		LA7	A3		OR8	
		LA8	A4			
		LA9				
		LA10				
		LA12*				
II	8	LA4		R2	OR1	Y6
					OR2	
					OR3	
					OR4	
					OR5	
III	6	LA1		R1*		Y2
						Y3
						Y4
						Y5
IV	2	LA3				Y1
V	1	LA11				
Total Patients -	31					

* Insufficient data for complete profiles; not included in averages.

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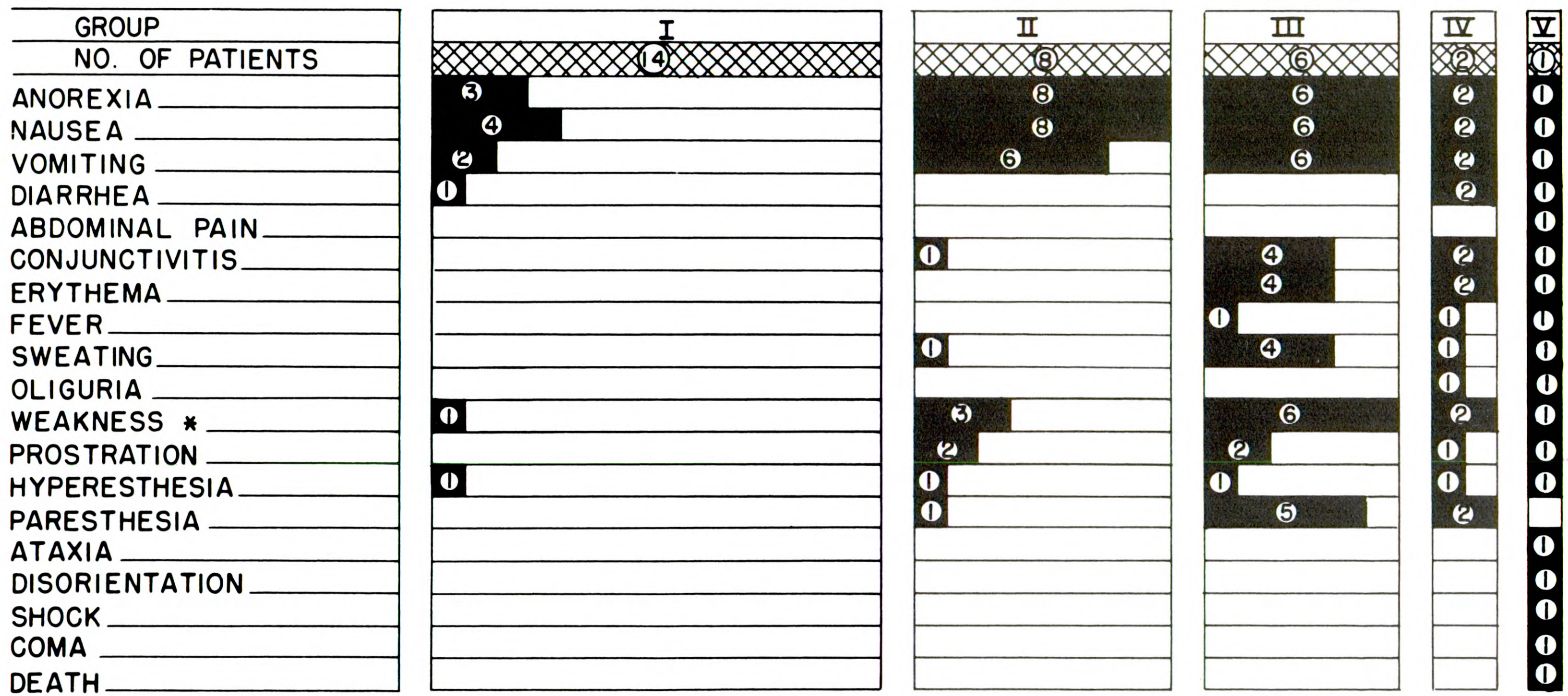

* INCLUDES FATIGUE

FIG. 4
FREQUENCY OF CLINICAL SIGNS AND SYMPTOMS - INITIAL STAGE

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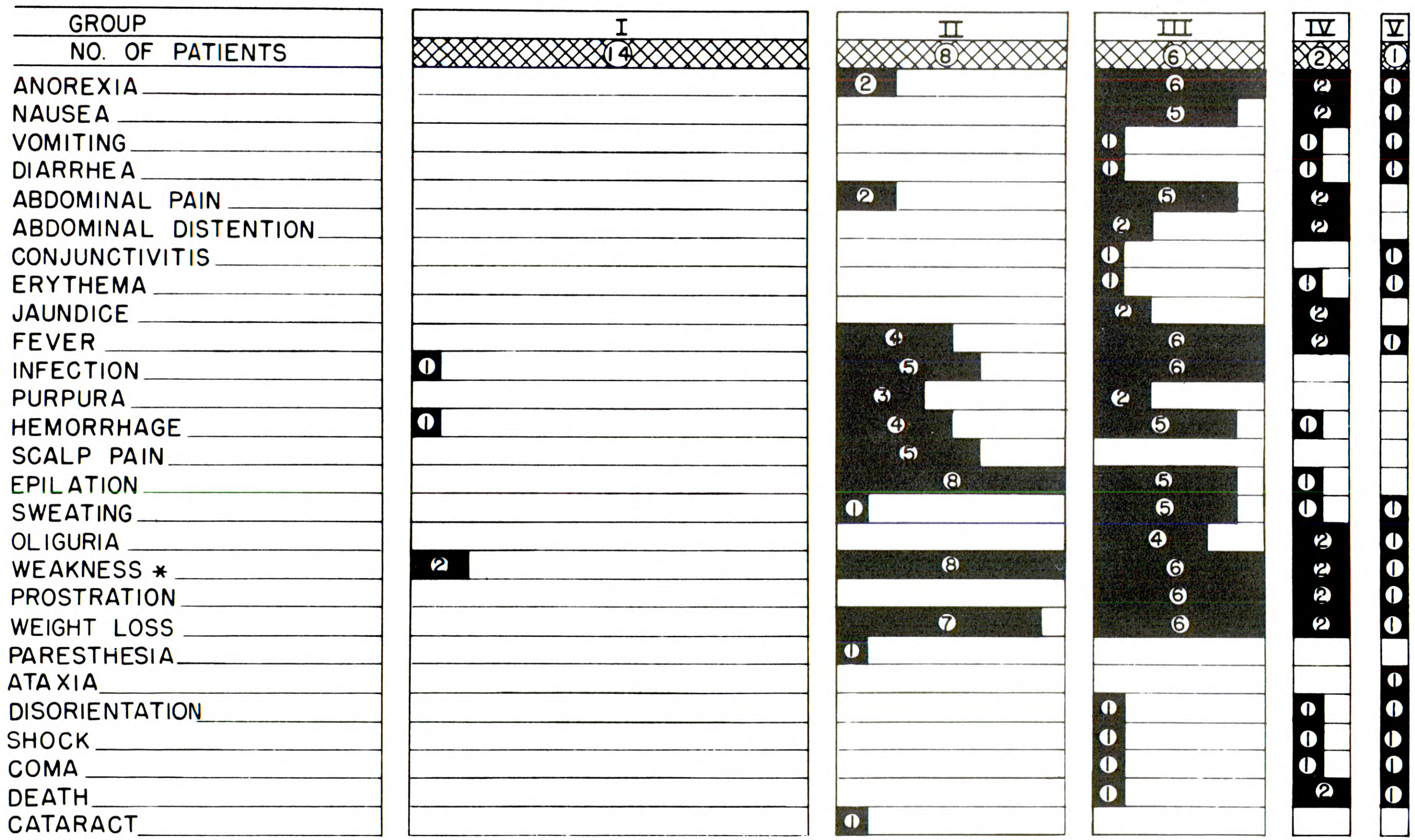

* INCLUDES FATIGUE

FIG. 5
FREQUENCY OF CLINICAL SIGNS AND SYMPTOMS
MANIFEST ILLNESS STAGE

TABLE IV – TIME OF ONSET AND DURATION OF CLINICAL SIGNS AND SYMPTONS – INITIAL STAGE

Group	I														II								III						IV		V
	LA2	LA6	LA7	LA8	LA9	LA10	LA12	A1	A2	A3	A4	OR6	OR7	OR8	LA4	R2	OR1	OR2	OR3	OR4	OR5	Y6	LA1	R1	Y2	Y3	Y4	Y5	LA3	Y1	LA11
Anorexia	....	....	....	....	6a(<1)	....	....	6(*1*)	....	3(1)	....	....	....	....	6(*12*)	*1*(4)	*2*(5)	2(1)	*2*(4)	*4*(3)	*2*(2)	*1*(1)	*1*(2)	*1*(3)	*1*(2a)	*1*(2a)	*1*(2a)	*1*(2a)	*1*(<1)	*1*(2a)	15m(*35*)
Nausea	....	....	....	....	6a(<1)	....	....	6(*1*)	....	3(1)	....	....	....	*2*(1i)	6(*12*)	*1*(4)	*2*(5)	2(<*1*)	*2*(4)	*4*(3)	*2*(2)	*1*(1)	*1*(2)	*1*(3)	*1*(2a)	*1*(2a)	*1*(2a)	*1*(2a)	*1*(<1)	*1*(2a)	15m(*35i*)
Vomiting	....	....	....	....	....	....	....	6(1)	....	3(1)	....	....	....	....	6(*1*)	*1*(4)	*2*(2)	....	*2*(4)	*4*(2)	2(*6*)	....	*1*(1)	*1*(3)	*1*(2a)	*1*(2a)	*1*(2a)	*1*(2a)	*1*(<1)	*1*(2a)	15m(*35i*)
Diarrhea	....	....	....	....	....	....	....	....	....	3(1)	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	4(1)	4(–)	45m(*35i*)
Abdominal pain	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	30m(*1*)
Conjunctivitis	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1(–)	....	....	1(–)	1(–)	1(–)	1(–)	–(–)	1(–)	30m(*35*)
Erythema	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1(14)	1(14)	1(14)	1(14)	1(9)	1(14)	30m(*35*)
Fever	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1(24)	....	....	....	....	....	*1*(9)	....	30m(*12*)
Sweating	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1(>90)	....	....	1(>90)	1(>90)	1(>90)	1(>90)	....	1(31)	*30*(*5*)
Oliguria	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	*1*(2)	....	<*1*a(*35*)
Weakness*	....	....	....	....	....	....	....	....	....	....	....	....	....	*2*(1)	1(70)	*1*(4)	....	....	....	....	....	1(>120)	*1*(24)	*1*(4)	1(>120)	1(>120)	1(>120)	1(>120)	*1*(1)	1(31)	5m(*35*)
Prostration	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1(10)	*1*(4)	....	....	....	....	....	....	*1*(1)	*1*(4)	....	....	....	....	*1*(1)	....	5m(*35*)
Hyperesthesia	....	1(<1)	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1(<1)	....	....	....	....	1(24†)	....	....	....	....	....	*1*(9†)	....	1m(*35*)
Paresthesia	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	*1*(2a)	*1*(1†)	....	*1*(2a)	*1*(2a)	*1*(2a)	*1*(2a)	*1*(–†)	*1*(2a)	....
Ataxia	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1m(*35p*)
Disorientation	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1m(*35p*)
Shock	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	30ma(*35p*)
Coma	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	*33*(*2*)
Death	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	*35*

Arabic number indicates postirradiation day of onset.
Arabic number *in italics* indicates postirradiation hour of onset.

Number in (parentheses) indicates duration.
* Includes fatigue.
† Limited to burned areas of upper extremities.
a Approximate time.
i Intermittent

m Minutes.
p Presumed.
t Includes terminal recurrence.
– Known to have occurred, but time unknown.
>More than, or later than.

<Less than, or earlier than.
NA Specific information about occurrence not available.
Leaders (....) indicate nonoccurrence.

TABLE V – TIME OF ONSET AND DURATION OF CLINICAL SIGNS AND SYMPTOMS – MANIFEST ILLNESS STAGE

Group	I														II								III						IV		V
	LA2	LA6	LA7	LA8	LA9	LA10	LA12	A1	A2	A3	A4	OR6	OR7	OR8	LA4	R2	OR1	OR2	OR3	OR4	OR5	Y6	LA1	R1	Y2	Y3	Y4	Y5	LA3	Y1	LA11
Anorexia	....	....	....	....	....	....	....	....	....	....	....	....	....	....	6(5)	24(20)	....	....	....	....	....	....	10(9†)	19(17)	30(6)	24(6)	30(6)	32(7)	6(4)	22(11)	15m(35)
Nausea	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	10(9†)	....	30(6)	24(6)	30(6)	32(7)	6(4)	22(11)	15m(35)
Vomiting	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	17(1)	....	....	....	....	....	6(4i)	....	15m(35)
Diarrhea	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	12(15)	....	....	....	....	....	7(3i)	....	45m(35)
Abdominal pain	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	24(1) †	....	....	21a(–)	10(4a)	....	31(6a)	29(6a)	29(6a)	29(6a)	6(4i)	22(9i)	....
Adbominal distention	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	10(4a)	....	....	....	....	29(6p)	6(4i)	22(9i)	....
Conjunctivitis	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	14(4a)	....	....	....	....	....	....	....	<0.5(35)
Erythema	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	3(23)	....	....	....	....	....	1(9)	....	<0.5(35)
Jaundice	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	25a(1p)	....	....	....	....	39(1a)	9(1†)	24(9a)	....
Fever	....	....	....	....	....	....	....	....	....	....	....	....	....	....	5(6)	24(9)	31(3)	....	....	13(1)	....	....	1(25)	19(17)	21a(14ai)	21a(14ai)	21a(14ai)	21a(14ai)	1(9)	4(10i†)	<0.5(35)
Infection	....	....	....	....	....	....	....	....	....	....	....	....	....	6(2a)	....	....	31(3)	10(10)	....	10(34a)	3(10)	....	10a(13†)	19(17a)	31(–)	29(–)	29(–)	29(–)	....	NA	....
Purpura	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	24(20a)	25(4)	....	....	....	....	....	....	19(22)	....	....	....	26(14)	....	....	....
Hemorrhage	....	....	....	....	....	....	....	....	....	....	15(<30)	....	....	....	....	24(20a)	25(2)	....	....	....	26(2)	–(–)	....	19(22)	26(18)	26a(20a)	26a(20a)	26a(20a)	....	27(6‡)	....
Scalp pain	....	....	....	....	....	....	....	....	....	....	....	....	....	....	17(>2)	13a(–)	16(4a)	....	16(4a)	....	16(4a)	....	....	....	....	....	....	....	....	....	....
Epilation	....	....	....	....	....	....	....	....	....	....	....	....	....	....	18(<30)	13(–)	17(27)	17(14)	17(>27)	17(10)	17(14)	20(<90)	17(10)	NA	14(<90)	16(<90)	18(<90)	17(<90)	....	14(18)	....
Sweating	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1(>90)	....	19a(>22)	1(>90)	1(>90)	1(>90)	1(>90)	....	1(32)	30(5)
Oliguria	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	30(6a)	24(7a)	30(6a)	32(7a)	8(2)	24(9a)	<1a(35)
Weakness*	3(60)	....	....	....	....	....	....	....	....	17(16)	....	....	....	....	1(70)	24(20)	30a(56a)	30a(56a)	44a(42a)	44a(42a)	44a(24a)	1(>120)	1(25)	19(22a)	1(>120)	1(>120)	1(>120)	1(>120)	1(9)	1(>120)	5m(35)
Prostration	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	6(21)	19(22)	30(6)	24(7)	30(6)	32(7)	6(4)	24(9)	5m(35)
Weight loss	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1p(20)	NA	1p(6)	....	1p(4)	1p(5)	....	>10(>120)	1p(25)	NA	1(<120)	1(>118)	1(>118)	1(<106)	1(9)	1(32)	1p(35p)
Hyperesthesia	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Paresthesia	....	....	....	....	....	....	....	....	....	....	....	....	....	....	15(10)	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Ataxia	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1m(35)
Disorientation	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	21a(4a)	....	....	....	....	....	7(3)	....	1m(35)
Shock	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	15(1) ¶	....	....	....	....	....	8(2)	NA	<0.5(35)
Coma	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	25(1)	....	....	....	....	....	8(2a)	NA	33(2)
Death	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	25	....	....	....	....	....	9	32	35
Cataract left	....	....	....	....	....	....	....	....	....	....	....	....	....	....	32 mo.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Cataract right	....	....	....	....	....	....	....	....	....	....	....	....	....	....	58 mo.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

Arabic number indicates post irradiation day of onset.
Arabic number *in italics* indicates post irradiation hour of onset.
Number in (parentheses) indicates duration.
* Includes fatigue.
† Patient had history of intermittent abdominal discomfort for several years.
‡ Epistaxis also occurred on day 14.

§ Epistaxis also occurred on day 12.
¶ Episode of supraventricular tachycardia. (History of previous episode.)
a Approximate time.
i Intermittent.
m Minutes.
p Presumed.

† Includes terminal recurrence.
– Known to have occurred but time unknown.
> More than, or later than.
< Less than, or earlier than.
NA Specific information about occurrence not available.
Leader (....) indicates nonoccurrence.

The time of onset and duration of clinical signs and symptoms in the early postirradiation period are given in Table IV. A similar compilation in Table V presents the clinical phenomena of the stage of manifest radiation illness. Where an early finding disappeared and then recurred after the latent period, it has been recorded as a new event. If, on the other hand, it persisted from the start, it has been recorded identically in both tables. Great variations in the completeness with which observations were made and reported, the many form of therapy employed, and the small number of cases involved afford a somewhat imprecise basis upon which to establish firm diagnostic and prognostic conclusions. Nevertheless, certain generalizations appear warranted.

1.3.1.1 Initial Stage. The classic prodromal gastrointestinal symptoms of the acute radiation syndrome, i.e. anorexia, nausea, and vomiting, were present in all patients in Groups III, IV, and V within an hour after exposure. They generally continued for about two days. In Group II the triad was somewhat slower in appearing, beginning within six hours, but continuing intermittently for another six hours. Two of the eight patients did not vomit at all. Only four of the 14 patients in Group I had anorexia or nausea, and only two of them vomited. In one of these, the symptoms occurred on the third day and were considered by the physician in charge as "a manifestation of anxiety and tension rather than radiation sickness".[3]

The occurrence of diarrhea in this stage seemed to be of serious

prognostic important. With the exception of the patient in Group I who had the anxiety reaction, this symptom occurred only in the Group IV and V cases, all three of which were fatal. It appeared on Day 4 in both Group IV patients. In the Group V patient it started in 45 minutes after irradiation, shortly after the onset of abdominal pain.

Weakness and fatigue were found in occasional patients in Groups I and II but were present and prolonged in all cases above that level of injury. Early prostration of short duration was also noted sometimes in Group II and above.

Other symptoms which were frequent almost exclusively in Group III and above included conjunctivitis, erythema, sweating, and paresthesias. Oliguria was seen in only one patient in Group IV and one in Group V.

Immediate central nervous system symptomatology, including ataxia, disorientation, and cardiovascular collapse, were seen only in the latter patient. He later became comatose and died about 36 hours after radiation exposure with no evident latent period in his illness. Each of the other patients had a period of remission of early symptoms before the manifest illness stage began.

1.3.1.2 Manifest Illness Stage. Patients in Group I showed no clinical evidence of illness of any kind after the initial stage subsided, except for one upper respiratory infection, one small retinal hemorrhage, and two complaints of weakness.

The most frequent finding above Group I was weakness and fatigue,

which occurred in all cases. Onset in Group II was most o, fifth or sixth week. In Group III and above it appeared almost immediately. Duration was variable but generally the symptom lasted for several months.

Another common finding in all groups above the first one was epilation. Time of onset ranged from 13 to 20 days, with 10 of 14 patients beginning to lose hair between Days 16 and 18. Two other patients, dyingin one and one-half and in nine days, did not epilate. No data are given in the remaining case. No clear relationship of time of onset or of duration to injury group is evident.

Scalp hyperesthesia or pain occurred in most Group II patients one or two days before epilation. No similar finding was noted in the higher groups.

Sporadic episodes of fever were observed in half of the patients in Group II and in all of those in Groups IV and V. These were of short duration in Group II, but lasted one or more weeks in most of the more severely injured patients.

Clinical evidence of infection was seen between the second and fourth weeks in half of Group II, including two of the four febrile patients. In Group III all cases showed such indications. Definite clinical infection was not noted in Groups IV and V.

Hemorrhagic phenomena, such as gingival bleeding, epistaxis, petechiae, and purpura, were observed in most cases above Group I who survived beyond the third week. Serious hemorrhage was limited to two patients in the fourth postexposure week. One, in Group III, had

menorrhagia and another in Group IV died with uncontrollable hematemeses and, finally, hemoptyses.

In Groups III, IV, and V a number of symptoms including recurrent anorexia and nausea, abdominal discomfort, prostration, and oliguria appeared at the peak of manifest illness. These findings occurred earlier in the more acutely ill patients, who also had the additional symptoms of vomiting, diarrhea, and abdominal distention. Disorientation, shock, coma, and death followed in several instances.

Jaundice was noted in mild transient form at the end of this period in two individuals in Group III and in more marked form terminally in the two Group IV patients.

Weight loss was mild and not of long duration in Group II. In higher groups it appears to have been severer but details are lacking.

The only long-term effect thus far reported has been the development of cataracts in one member of Group II.

1.3.2 Clinical Laboratory Findings

The radiation accident patients discussed in this report underwent a large number of laboratory examinations of many varieties. These are summarized in Appendix Tables A-I, A-II, A-III, and A-IV, covering hematology, blood biochemistry, urine biochemistry, and miscellaneous categories. In order to consider and compare the numerous laboratory observations, it was clearly necessary to develop a procedure for their analysis which would allow broad conclusions to be drawn despite differences in details of methodology employed in the

diverse study centers.

1.3.2.1 Method of Presentation and Analysis. The accepted normal range of results of each test procedure which was widely used among the cases under study, or which is recommended for such future use, was compiled. A scoring system was then devised which assigned values increasing from one to four to increasing deviations from the normal range. Using the resultant values, "profiles of injury" could be scored for the individual patients whose laboratory findings were available. These have been called "profile scores". The values assigned to the various deviations from the normal range therefore have been designated "profile values".

The profile values for hematological tests are given in Table VI. Profile values for coagulation tests and for biochemical tests of blood and urine are presented in Appendix Tables A-V, A-VI, and A-VII. Profile values were not assigned to tests for which there is insufficient clinical laboratory experience.

Profile scores were determined for all possible tests in each individual case. These were analyzed on the basis of single test scores hereafter referred to as "test score". Cumulative totals of these test scores over the postexposure time period were also analyzed. These cumulative totals are referred to hereafter as "cumulative scores". Then, to facilitate intragroup comparisons, an attempt was made to determine the mean profile score for each radiation injury group on each type of test procedure at various convenient postexposure

Table VI

Profile Values Assigned for Various Ranges of Abnormality

Hematology - Peripheral Counts

Test	Units	Normal*	Increase (above)				Decrease (below)			
			1	2	3	4	1	2	3	4
Hemoglobin	gms %	M-15.8	18	19	20	21	14	12	10	8
		F-13.9	16	17	18	19	11.5	10	8.5	7
Erythrocytes	mill/mm^3	M- 5.4	6.0	7.0	8.0	9.0	4.5	3.5	2.5	1.5
		F- 4.8	5.5	6.5	7.5	8.5	4.0	3.0	2.0	1.0
Hematocrit	vol. %	M-47	54	56	58	60	40	35	30	25
		F-42	47	49	51	53	37	32	27	22
Leucocytes	1000/mm^3	7.4	12	18	24	30	4.0	3.0	2.0	1.0
Neutrophils	1000/mm^3	4.4	7.7	14	21	28.0	1.8	1.3	0.9	0.5
Lymphocytes	1000/mm^3	2.5	4.8	7.0	10	12.0	1.0	0.75	0.5	0.3
Platelets	1000/mm^3									
Rees-Ecker		405	545	700	850	1000	273	200	100	30
Brecher-Cronkite		257	440	600	750	900	140	100	50	30
Fonio		234	350	500	650	800	130	100	50	30
Dameshek		716	900	1000	1500	2000	500	350	100	30
Reticulocytes	% RBE	1.5	4	8	15	25	0.5	0		
Erythrocyte Sedimentation Rate	mm/hr	M- 5	10	20	30	40				
		F-10	20	30	40	50				

*Expressed as "universal mean" value - taken from Albritton.[19]

time intervals.

Unfortunately, it was found that only in the category of hematological tests was there a sufficient number of observations performed at times which were sufficiently uniform in a sufficiently large number of the accident patients to permit determination of mean profile scores for each clinical radiation injury group. It is possible, however, that profile scores for other tests might be useful in the future, provided that they are performed at relatively frequent and consistent intervals. For this reason, suggested profile values for ranges of abnormalities of standard blood clotting, blood chemistry, and urine chemistry tests were included in the Appendix tables, as were all available individual scores.

1.3.2.2 Hematology

Peripheral Blood Counts. Previous reports have indi- the usefulness of one or more of the components of the peripheral blood count as an indicator of radiation injury.[2,8,20,21] Granulocytes, lymphocytes, monocytes, platelets, and reticulocytes have been shown to contribute helpful information. The hematological data in the accident cases have been reviewed with two main considerations in mind. The first is their potential value in the assignment of an unknown case to a specific injury group, with all the diagnostic and therapeutic implications involved. The second is the usefulness of these data in the detection of complications or therapeutic responses in the subsequent course of the case.

The total blood count profile score is made up from the scores for counts of erythrocytes or hematocrit, leucocytes, granulocytes, lymphocytes, and platelets. Other blood components were omitted on the grounds of infrequency and irregularity of testing. The results were considered on an individual and group basis. Test scores and their cumulative scores were tabulated.

The individual blood count profile scores, including test scores and cumulative scores, are given in Appendix Table A-VIII. The test scores are also presented graphically in Figs. A-1 through A-16. The cumulative blood count scores with the ranges and means for all the injury groups are given in Appendix Table A-IX. The range and mean of the test scores and their cumulative scores also are tabulated by groups in a different way in Appendix Table A-X. A graphic treatment of the mean and range of total blood count test scores is shown in Figs. 6 through 9. Figure 10 depicts graphically the cumulative blood count scores of all patients to 120 days after exposure. A graph of the range and mean of group cumulative scores is shown in Fig. 11.

Study of these data shows that variations in the rate and magnitude of accumulation of injury over time, as measured by hematologic tests, are closely related to the signs of clinical injury upon which injury group classification was based in each case. It is possible to separate the mean score of cases falling into Group I and II from those of the more severely injured groups at 48 hours or less. Group V was distinguishable from the outset. By the sixth day, Group I was distinct from II, and III from IV.

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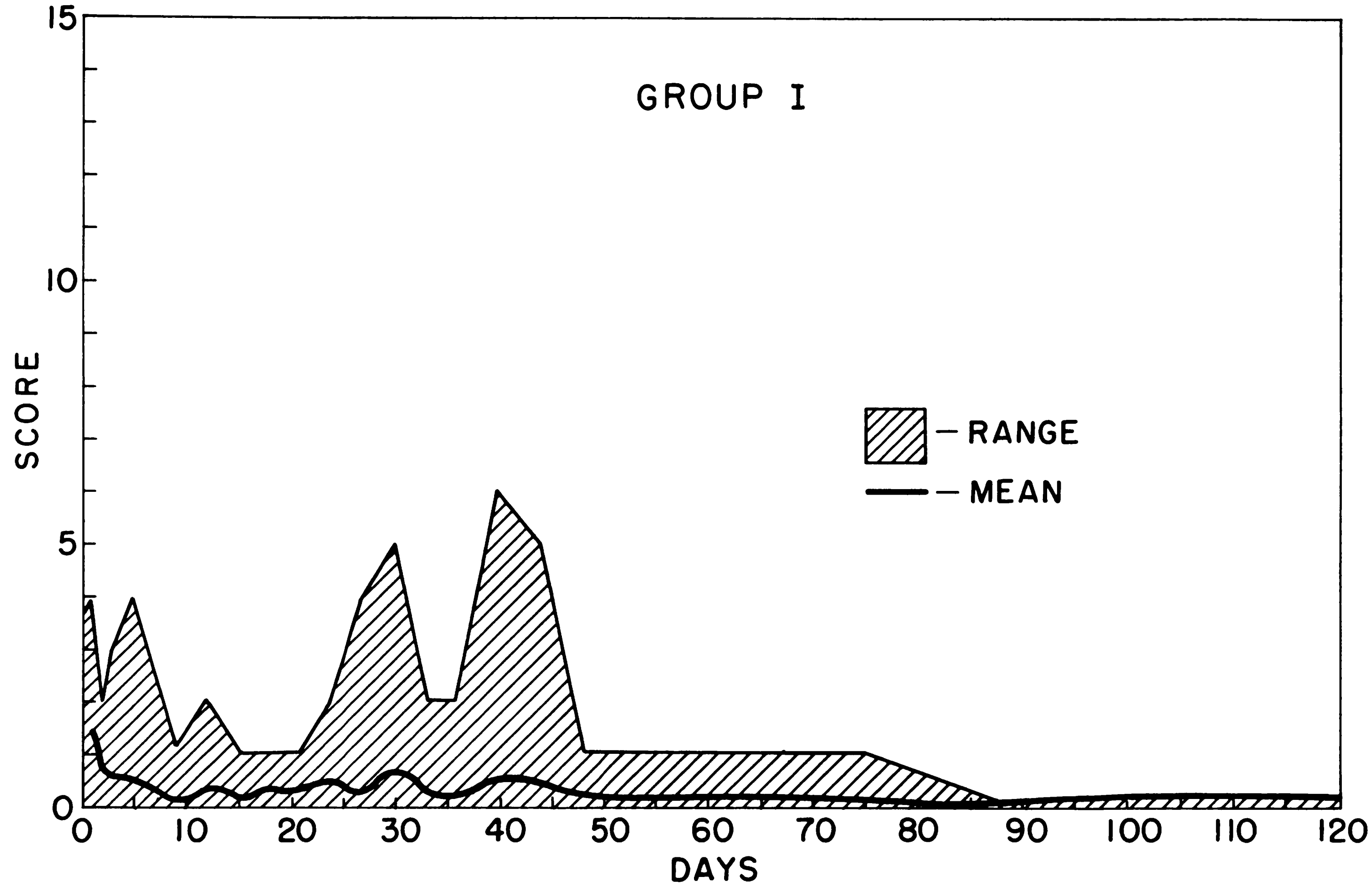

FIG. 6

MEAN TEST PROFILE SCORES–HEMATOLOGY
TOTAL BLOOD COUNT–GROUP I

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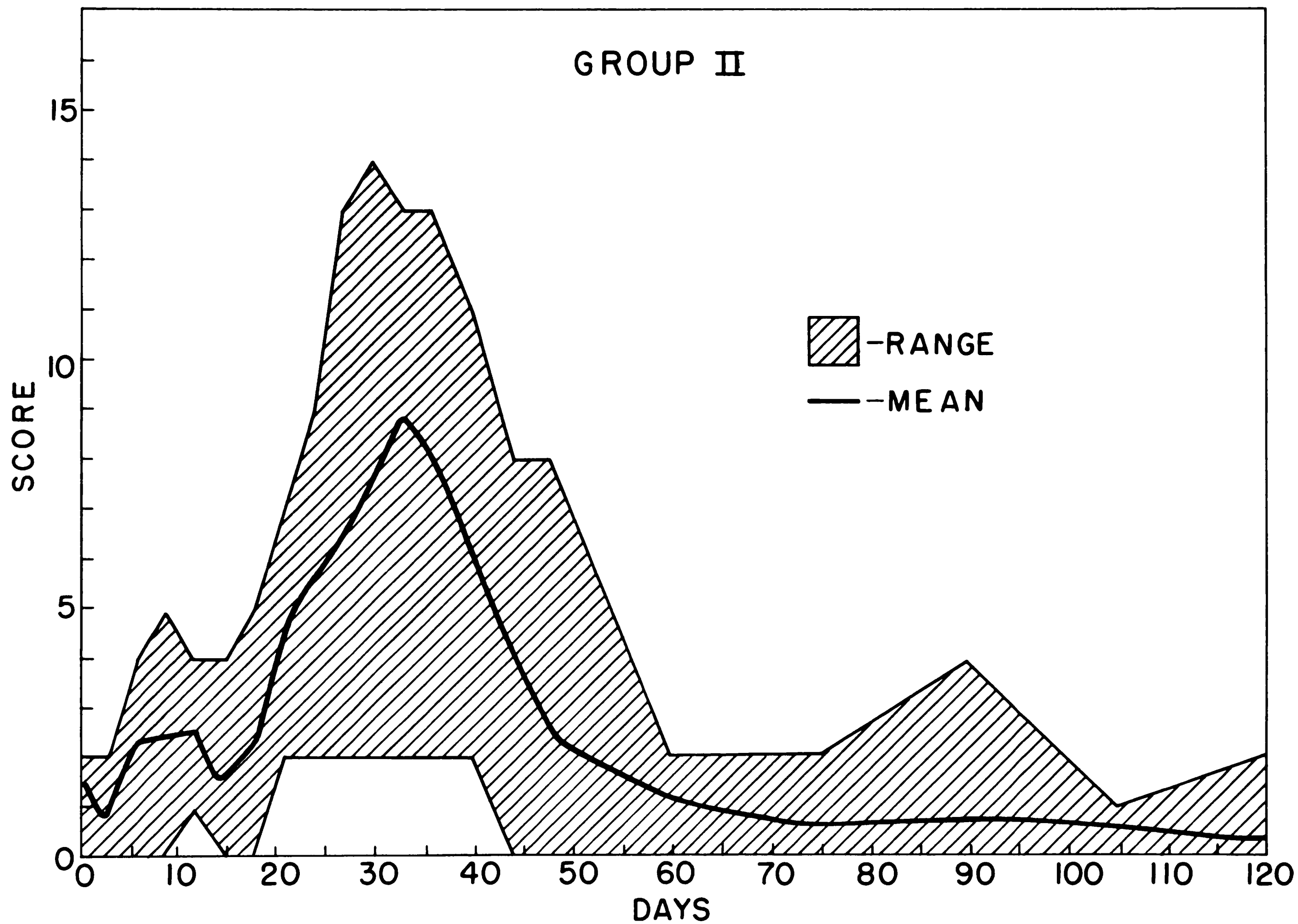

FIG. 7
MEAN TEST PROFILE SCORES-HEMATOLOGY
TOTAL BLOOD COUNT-GROUP II

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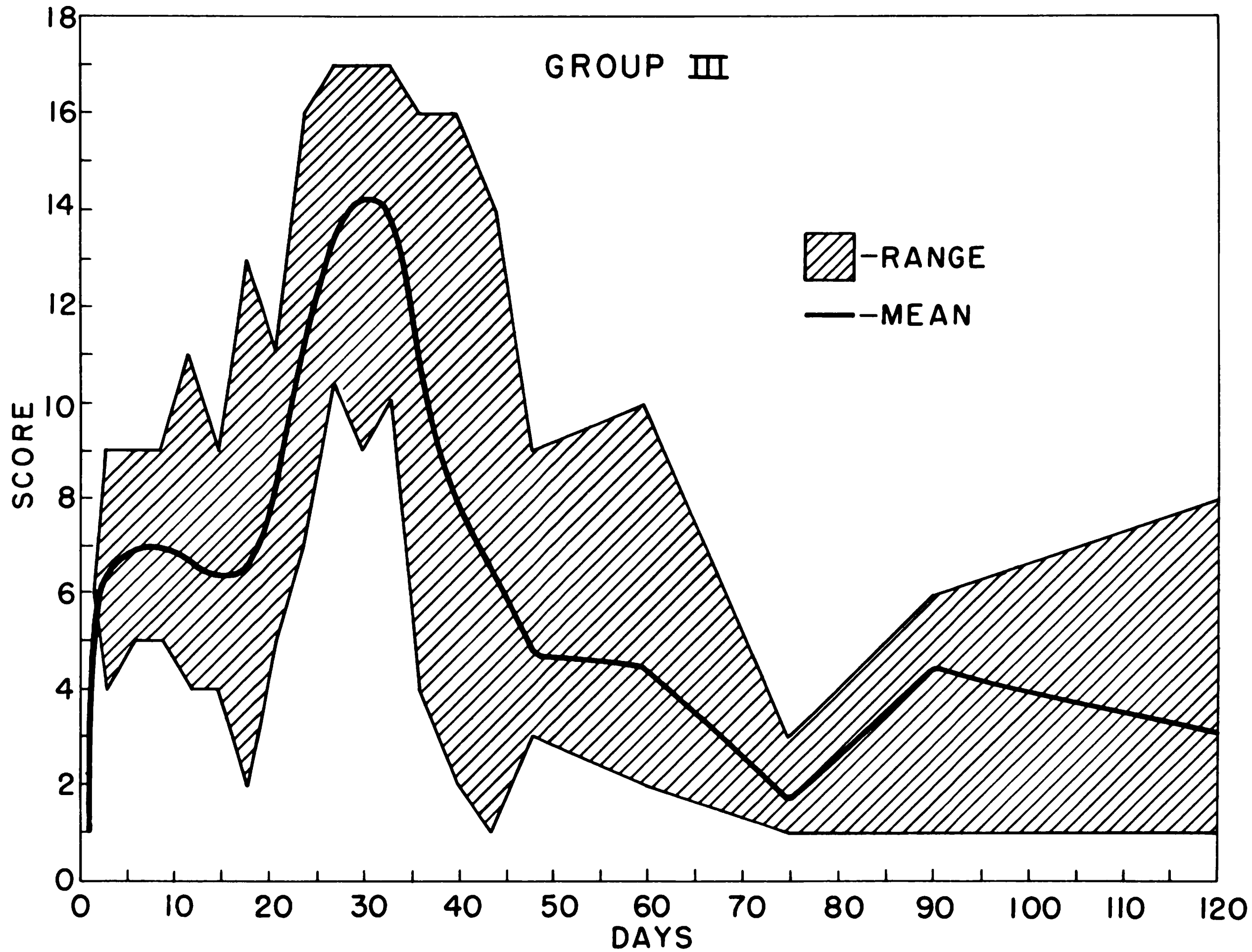

FIG. 8

MEAN TEST PROFILE SCORES-HEMATOLOGY
TOTAL BLOOD COUNT-GROUP III

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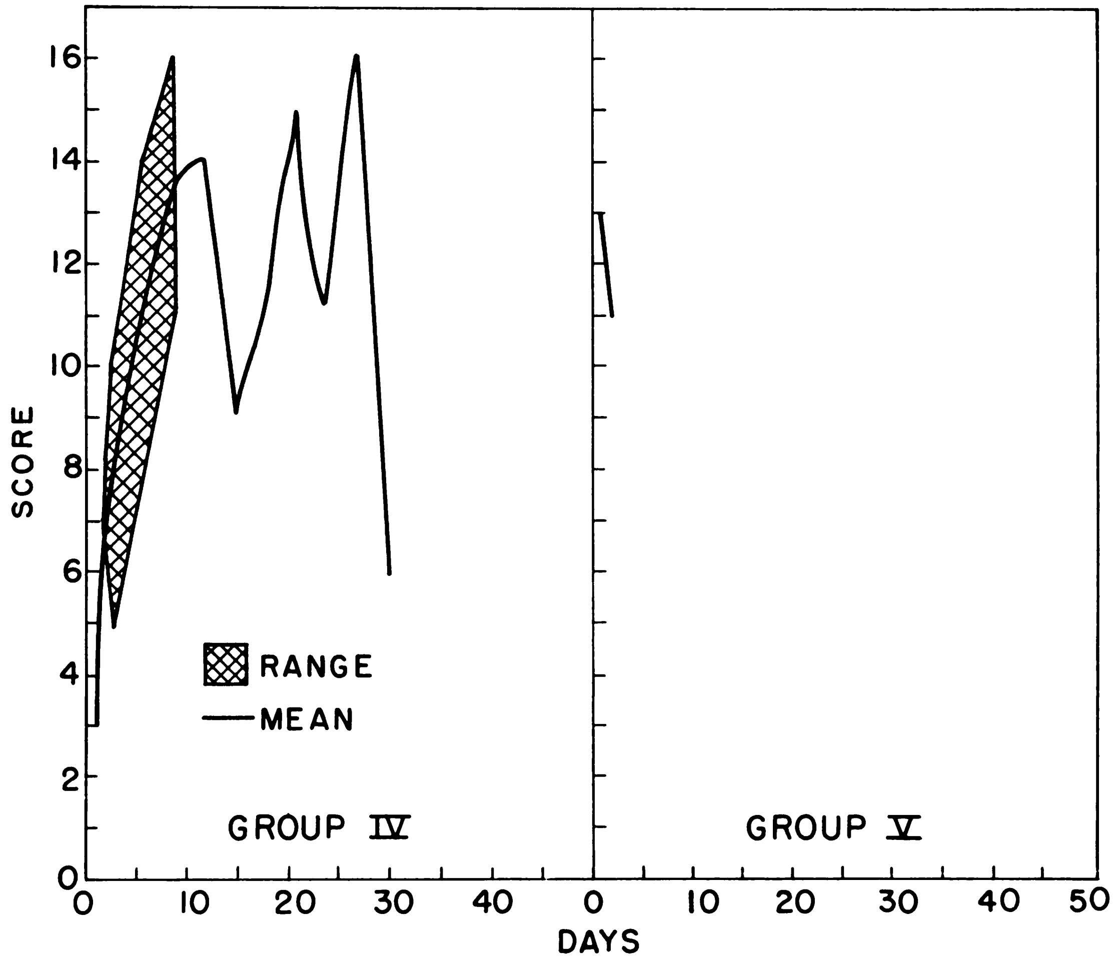

FIG. 9
MEAN TEST PROFILE SCORES-HEMATOLOGY
TOTAL BLOOD COUNT-GROUPS IV & V

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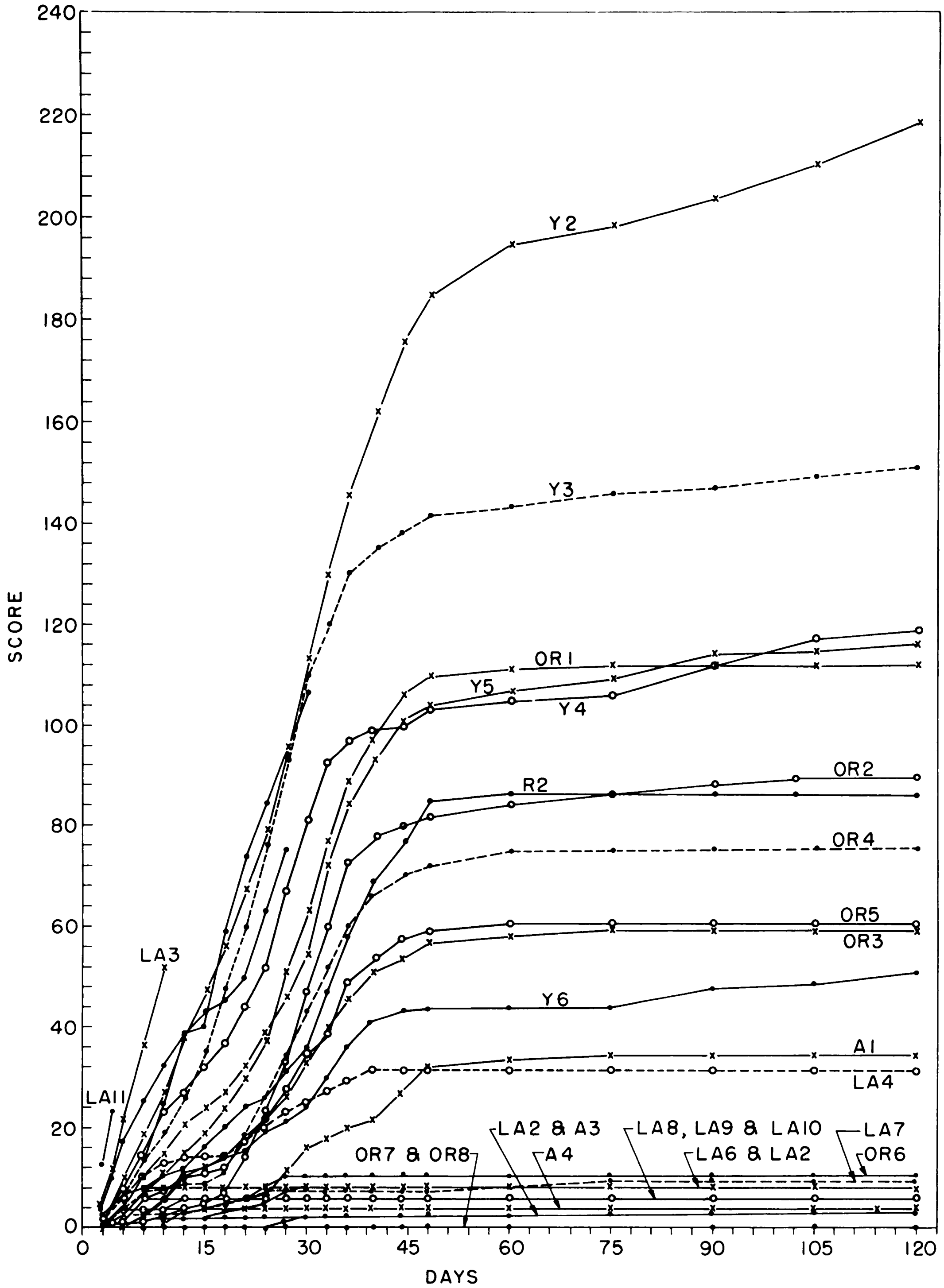

FIG. 10

INDIVIDUAL CUMULATIVE PROFILE SCORES THROUGH 120 POSTEXPOSURE DAYS
HEMATOLOGY - TOTAL BLOOD COUNT

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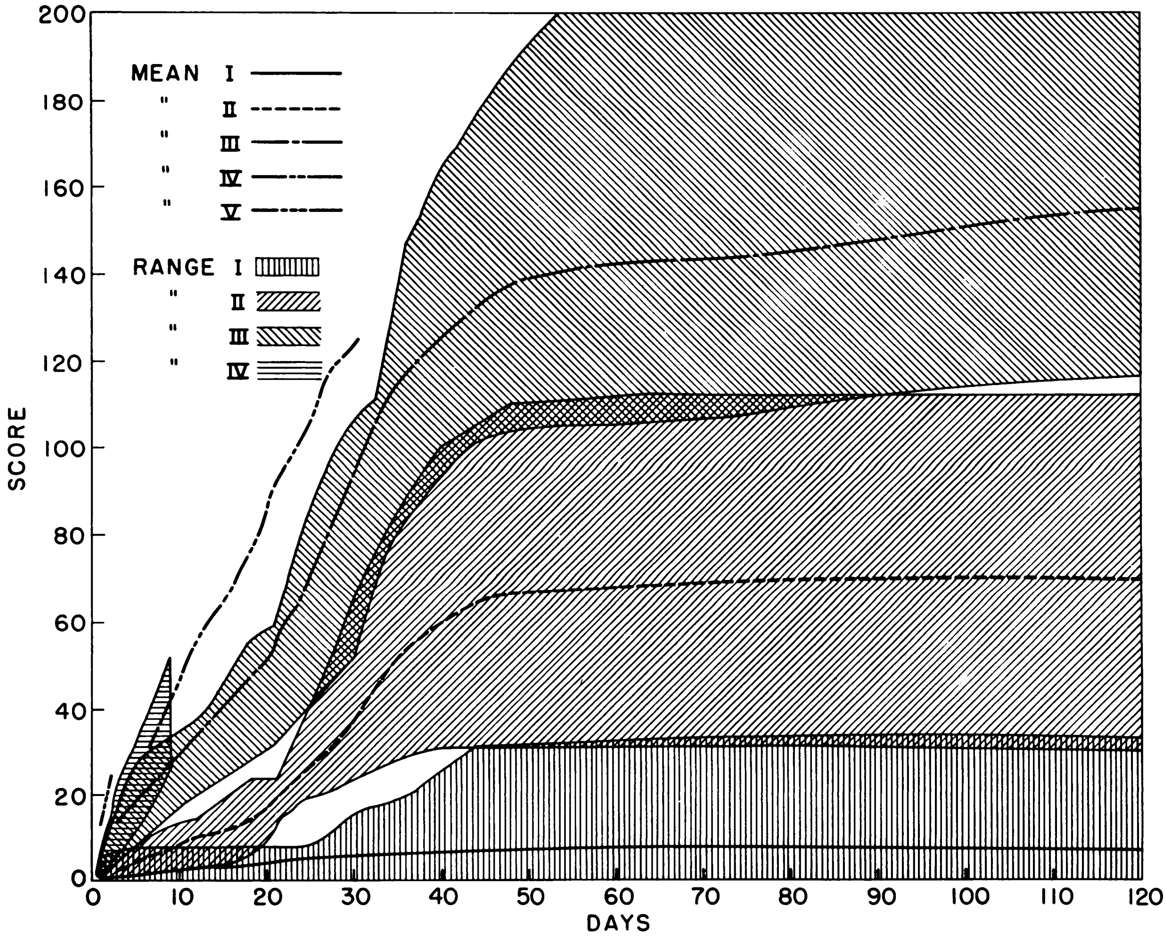

FIG. 11

GROUP MEAN CUMULATIVE PROFILE SCORES-
HEMATOLOGY - TOTAL BLOOD COUNT

Examination of the ranges of the cumulative group mean scores portrayed in Fig. 11 emphasizes the value of the blood count in indicating radiation injury. It also makes clear the difficulty of relying solely on this measure in the initial stage of radiation illness when there is considerable overlapping of the ranges of the group profile scores.

If one wishes to refine the estimation of injury group assignment, certain individual tests which were added together to form the previous total scores may be considered separately. To facilitate this analysis, the mean cumulatives of each component of the total blood count profile score have been graphed in Appendix Figs. A-17, A-18, A-19, A-20, A-21, and A-22.

The lymphocyte scores appear to be the best early single laboratory indicator of radiation injury. In 48 hours Group II, III, IV, and V are well separated in mean score. However, a few of the Group II cases show little early lymphocyte fall while the opposite occurs in Group I thereby producing some overlapping of the lowest two groups. If one considers the presence or absence of prodromal (nausea and/or vomiting) symptoms in addition to the lymphocyte score in assigning patients to these two groups, the likelihood of correct decision is enhanced.

The neutrophil score did not facilitate differentiation of Groups I and II. Nevertheless, it was useful supportive evidence in separating the two lower groups from the three higher ones by Day 3. Also Groups III and IV were becoming distinct on Day 3 by this criterion. However, Group I and II were not distinguishable for the first

month.

The leucocyte score gave rather similar information but not as distinctly as did the neutrophil score. This was, of course, a reflection of the fact that neutrophil variations account for most of the white count changes, although lymphocyte shifts are also involved. Thus the distinction between Group I and II was present earlier here than in the neutrophil score.

The platelet score was not very useful in the early days after exposure. However, the differentiation of Group IV from Group III was apparent by this test as early as Day 6. After the third week, sharp changes separated Groups II and III from unaltered Group I.

Erythrocyte scoring was the least helpful of the blood count tests. The severity of injury of Group III was greater than that of Group IV by this test. A difference between Groups II and III was discernable after the first month. Therapeutic effects such as transfusion, and some pre-exposure abnormalities confused the interpretation of the data from this test.

The value of hematological profile scores as an indicator of complications is not certain. Generally, neutrophil or platelet levels were lowest when infection or bleeding began but this was not always so. Distinct deviations of an individual case from the group pattern during the course might indicate complications. However, more data are needed to define the ranges of the group patterns before this relationship can be evaluated adequately.

Deviations caused by therapy other than blood transfusions already

mentioned may have occurred in the Yugoslav cases. The near normal neutrophil scores of Y1 on Days 15 and 18 follow embryonal myeloid tissue transfusion and the one on Day 30 follows adult marrow transfusion. The platelet score on Day 30 also is normal. Since Group IV data are based on Y1 alone after Day 9 because of the death of LA3 at that time, the results in this group are affected thereby. Similar effects of marrow transplantation in cases Y2, Y3, Y4, and Y5, all in Group III, may be responsible for the improvement of that group's neutrophil and platelet scores somewhat earlier than those of Group II.

Other Hematological Tests: Bone Marrow. Examinations were made at various times in many of the cases. However, classification of results on quantitative basis is not possible so no profile scoring could be devised.

In general, the relationship between the appearance of the bone marrow and the degree of injury, or its prognosis, is not obvious. There is hypocellularity beginning in the early postexposure period, characterized by depression of the granulycytic series in particular. Mononuclear cells of the reticulum and plasma cell varieties remain, with variable concentrations of erythroid precursors. Numerical diminution and morphologic deterioration of megakaryocytes develop a little later. Regeneration of erythroid and myeloid precursors may develop even when the peripheral counts are falling and the outcome is subsequently fatal.

Reticulocytes. These data were insufficient for quantitative analysis. Depression in number was generally prompt, but its magnitude

was not clearly related to injury level. Reticulocytosis was an indication of recovery. A possible direct relationship between the level of reticulocytosis and the extent of previous injury has been postulated.[8]

<u>Erythrocyte Sedimentation Rate</u>. The results of this test were available serially only in the Oak Ridge cases. They are presented in Table VII. Here a close relationship of elevation to the early stages of infection seems to have been present. However, the abnormality persists far beyond the duration of the infection which it seemingly heralded. Further data would be helpful in evaluating the apparent usefulness of this test as a warning of infection at a time when the usual signs, such as fever or leucocytosis, may not be present.

<u>Blood Coagulation Tests</u>. Inspection of Appendix Table A-XI reveals that coagulation tests were not made with any regularity. The coagulation time was the test most consistently performed. Patients LA3, LA4, and LA6 showed significant time prolongations. The maximum deviation occurred on Day 6 for LA4 and LA6. LA3, a Group IV patient, showed a progressive prolongation of the clotting time. Just prior to death on Day 9, his blood was uncoagulable. An increase in clotting time was noted on many occasions in various patients from the Yugoslav accident.

A variety of tests designed to measure components of the prothrombin complex were carried out in some of the cases. In general, there was no evidence of derangement, except in a few of the most severely injured patients. The plasma prothrombin time was moderately

Table VII

Erythrocyte Sedimentation Rate Profile Scores

Group II - Oak Ridge Patients

Day	OR1	OR2	OR3	OR4	OR5
1	0	0	0	0	0
2	0	0	0	0	0
3	-	0	0	0	0
6	0	0	0	0	0
9	0	1 (10)*	1	1 (10)*	0
12	0	1	0	2 (13)*	0
15	0	1	0	3	0
18	0	1	0	3	0
21	0	1	0	2	0
24	0	1	0	2	0
27	-	-	-	-	-
30	1 (31)*	2	1	2	0
Total	1	8	2	15	0
33	1	2	1	2	0
36	1	2	0	2	-
40	1	1	1	1	0
44	1	2	0	1	0
48	0	2	-	1	0
52	1	1	0	1	0
60	1	1	1	1	0
75	1	2	1	1	0
90	0	1	0	1	0
105	1	1	1	1	0
120	1	1	2	1	0
150	3	1	1	1	0
180	2	1	1	2	0
270	0	1	1	1	0
Total	15	27	12	32	0

* Day on which infection became clinically evident

increased in LA3. A decrease in Ac-globulin and proconvertin was noted in Y2. The tourniquet test was positive in many determinations made on the Yugoslav patients, especially patients Y4, Y5, and Y6. Of the five Oak Ridge patients in Injury Group II, four had elevated levels of Ac-globulin; all had distinctly elevated levels of antihemophilic globulin at the peak of their thrombocytopenia. These abnormalities of the plasma clotting factors are believed to be related, at least in part, to the thrombocytopenia.

1.3.2.3 Biochemistry. The blood electrolytes were measured in practically all of the patients. Scores, tabulated in Appendix Table A-XII, failed to reveal any significant abnormalities, other than those associated with prolonged vomiting or diarrhea. Nitrogen retention was noted in all patients exhibiting oliguria. Calcium and phosphorus metabolism appeared to be unaltered, except in the case of LA3, in which there was a decrease in blood calcium, as would be expected in a patient with severe nitrogen retention.

Total protein measurements and electrophoretic fractionation were carried out on practically all Group-II, III, and IV patients. The results of these determinations were extremely variable and inconsistent. There was evidence of hyperbilirubinemia in patients LA3, LA1, and Y1, either terminally or at post mortem. A number of other biochemical procedures were carried out, none of which revealed any significant abnormalities.

Urinary output was recorded for all patients except R1 and R2,

as indicated in Appendix Table A-XIII. In all cases in Groups III, IV, and V, except LA1, a decrease to oliguric levels was noted during the critical period of the manifest illness stage. There were no significant effects in either total nitrogen, amino nitrogen, or uric acid excretion in the Group II Oak Ridge patients.

Quantitative determinations of urinary amino acids were made in most of the cases in all groups. Although normal values are given in Appendix Table A-XIV, no profile values are presented due to past procedural variations. Increased excretion of a variety of these was noted as early as 12 hours postirradiation, but there was no apparent quantitative relation to radiation dose (see Appendix Table A-XV). A newly discovered urinary amino acid, beta-aminoisobutyric acid (BAIBA) was excreted in increased amounts by the Oak Ridge patients in Group II. Excretion was maximum during the first few days after exposure and returned to normal by Day 10. As shown in Appendix Table XVI, the magnitude of the increase in excretion of BAIBA in these cases appears to be related to dose.

Significant increases in bile pigment excretion was noted in LA3, LA4, and occasionally in some of the Yugoslavs. There was presumptive evidence of an increase in LA1. The increase in coproporphyrin excretion in LA4, Group II, first occurred and was at the highest level on Day 2. It recurred intermittently through Day 13. An increase in urobilinogin was noted only on Day 6.

1.3.2.4 Miscellaneous Observations. Bacteriologic procedures carried out on a number of patients in all groups were not particularly helpful. Occult blood was found in the stools of several patients in Groups II through V at the time of the other hemorrhagic manifestations.

Seminal fluid examinations made on the male Argonne patients showed an aspermia by the tenth month in A1, the patient receiving the highest dose. In all of the surviving male Yugoslav patients there were marked quantitative and morphologic changes in the sperm. At autopsy on patient Y1, a total depopulation of the seminiferous tabules was found. Similar findings were noted in LA1 and LA3 at autopsy. LA4 had an aspermia at the seventh month which persisted for 17 months. Testicular biopsies in this patient revealed marked atrophy at the tenth month. Biopsy 50 months postirradiation again revealed atrophy but there was evidence of partial regeneration.

Slit lamp examinations of the optic lens were made in most of the non-fatal cases. Only one, LA4, has developed lens opacities to date. The first was noted in the left eye at 32 months postexposure and by 58 months an incipient cataract in the lens of his right eye had developed. Transient changes occurred in the Yugoslav patients.

1.3.3 Clinical Management

The methods of therapy utilized in the clinical management of the radiation accident cases will be considered in this section together with the results obtained. A tremendous variety of therapeutic materials have been employed. Only general classes of agents,

summarized in Table VIII, will be discussed.

It will be noted that only in cases which fall into Injury Groups II through V was active therapy necessary. In general, the clinical approach has been supportive with specific treatment being reserved for symptomatic indications. However, active prophylactic treatment was carried out in the two Russian cases. Certain other cases also received prophylactic antibiotics.

Antiobiotics were the most widely used form of therapy in these cases. Indications ranged from overt prophylaxis in the two Russian cases to agranulocytosis in LA1, and to various indications of possible infection such as temperature elevation and the like in the remaining cases so treated. Agents employed covered the gamut of antibiotic forms of therapy, the choice depending primarily on the date of occurrence of the accident and the antibiotic in vogue at that time. It is difficult to evaluate the benefits of this form of therapy. When used as specific treatment for an obvious infection, the usual benefit was noted. As a less specific treatment for less obvious symptomatology, its value cannot be measured. There were no unusual side effects.

Whole blood transfusions comprised the next most popular form of treatment. These also were used both prophylactically and therapeutically. The six Yugoslav cases each received 150 cc of whole blood on the third day after exposure in order to offset the iatrogenic blood loss which preceded the transfusion. The Russian patients both received transfusions of 200 cc of whole blood once every three

Table VIII

Summary of Therapeutics Employed in Radiation Accident Cases

Therapy	Group II								Group III						Group IV		Group V
	LA4	R1	R2	OR1	OR2	OR3	OR4	OR5	Y6	LA1	Y2	Y3	Y4	Y5	LA3	Y1	LA11
Sedation						X											X
Analgesics		X				X				X					X		X
Antiemetics				X		X	X	X									
Antispasmodics		X				X											
Parenteral fluids	X									X					X		X
Whole Blood	X	X	X						X	X	X	X	X	X	X	X	
Plasma	X														X		X
Platelets											X	X				X	
Bone marrow											X	X	X	X		X	
Antibiotics	X	X	X	X			X		X	X	X	X	X	X	X	X	
Vascoconstrictors																	X
Vitamins		X	X						X	X	X	X	X	X		X	
Hematinics		X	X														
Miscellaneous		X	X							X						X	

X - Therapy used one or more times

to five days from the first day on. The other cases received transfusions as their clinical situations warranted. Plasma transfusions were used in the various Los Alamos cases to combat protein depletion from local burn injury. Also, in the most recent Los Alamos case, LA11, plasma was used as a blood volume expander in an effort to combat clinical shock. Platelet transfusions were employed in Y1, Y2, and Y3 during a phase of clinical bleeding. Some benefit from this form of therapy was evident both clinically and by laboratory tests.

Bone marrow transplantation, a relatively new form of therapy, was utilized to treat all the Yugoslav cases except Y6. It was felt that the last mentioned case was not sufficiently injured to justify the utilization of this novel form of therapy. The most severely injured patient, Y1, was first given a transfusion of embryonic myeloid cells on the 14th day after exposure. No clinical or hematological changes were observed in the days that followed. About two weeks later he and the other four patients received adult bone marrow transfusions. The marrow was obtained by multiple aspirations from individual homologous donors who were matched in sex and in major and most minor blood subgroups.

In the case of Y1, a rapid improvement in the granulocyte and platelet counts appeared within four days. Unfortunately, however, deterioration of the clinical picture continued, with intestinal obstruction and renal failure ensuing. Following hemodialysis, the patient died of a major hemorrhage in the respiratory tract. The other four cases showed prompt hematological and clinical improvement

after the bone marrow transfusion was given. Fever, weakness, anorexia, and weight loss ceased. Significant elevations of granulocyte, platelet, reticulocyte, and, later on, of erythrocyte counts was observed. All of these phenomena occurred at an earlier time than they did in the one patient who did not receive the marrow transfusion because he was deemed less seriously injured than the others. There was some evidence (based on Ashby techniques of erythrocyte agglutination counting) that the improvement was accompanied by an increasing number of cells of the donor type in the recipients. The rise and subsequent fall in the incidence of donor cells in these patients occupied a period of about one month. The rate and time of appearance of these donor erythrocytes in the hosts suggests that there may have been actual blood production by the transplanted donor tissue for a short period of time. There was no clinical evidence of any form of foreign tissue reaction, so called "secondary disease",[15] in these patients at the time when the donor cells were disappearing from the circulation.

Antiemetics were used in the early prodromal stage after exposure in the Oak Ridge cases. There is no conclusive evidence of their efficacy. Various other supportive measures such as sedation, analgesia, antispasmodics, vitamins, hematinics, and parenteral fluids were employed in various instances.

1.4 Correlation of Clinical Injury with Radiation Dose

Having reviewed the clinical and laboratory findings of the

accidental radiation injury cases in the foregoing section, 1.3, it would be of great interest to determine how well the evidences of clinical injury correlate with the physical dosimetry data in these cases. Unfortunately, the variety of clinical observations of signs and symptoms and the absence of any standardized methods of collecting and reporting these results preclude any testing of their correlation with the dosimetry data. However, some evidence has been presented in the foregoing section to indicate that hematological laboratory findings do correlate well with the general classification of patients in terms of the overall extent of clinical signs and symptoms. The hematological findings, therefore, have been tested for their relationship to the best estimates of physical dose in each case. Some aspects of this analysis will be presented herein.

The cumulative blood count injury score for 120 days following radiation exposure was selected as an appropriate index for this analysis. This was used because it was felt that all or almost all of the manifestations of hematological damage had occurred and that recovery was quite complete at the end of 120 days in most of the cases studied. One unavoidable result of this selection was that the four cases, LA11, Y1, LA3, and LA1, who died before 120 days were not included in the analysis. In Fig. 12 the total cumulative blood count profile scores through the 120 days are plotted against the best estimate of dose for each case. Figures 13 through 17 depict a similar plotting of the white count, the lymphocyte count, the neutrophil count, the erythrocyte count, and the platelet count,

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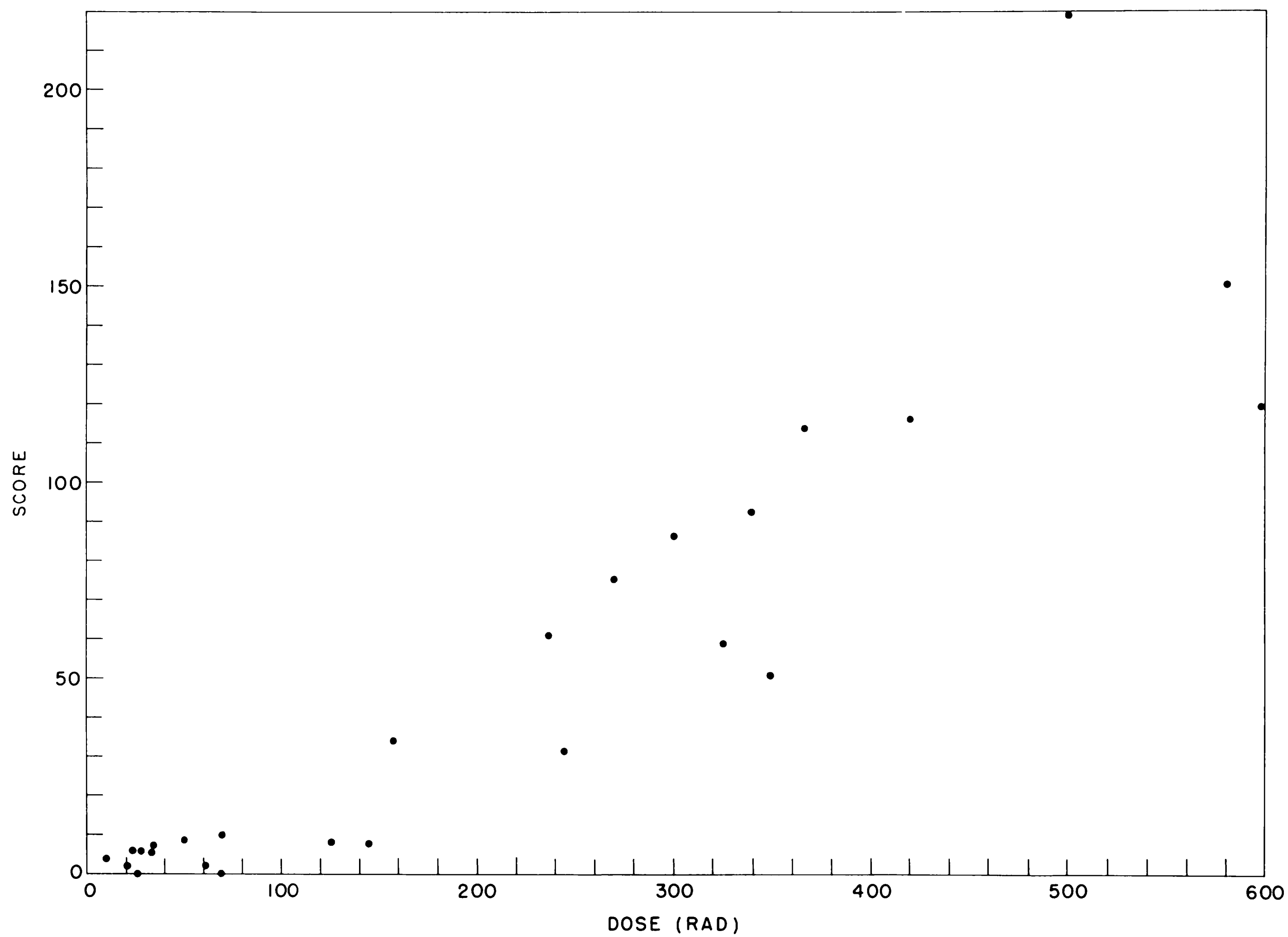

FIG. 12
RELATIONSHIP OF 120-DAY POSTEXPOSURE CUMULATIVE SCORE TO DOSE-HEMATOLOGY-TOTAL BLOOD COUNT

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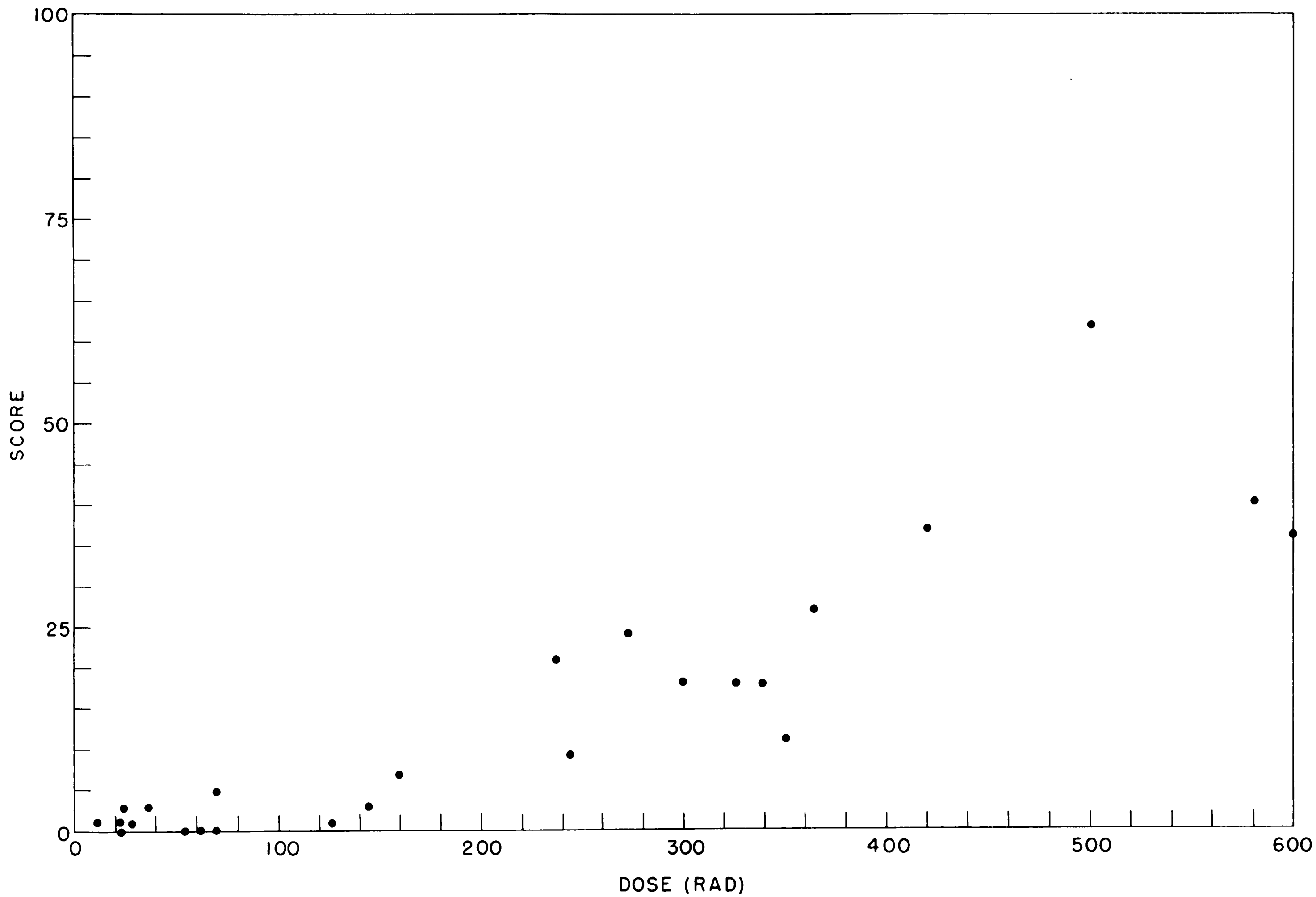

FIG. 13
RELATIONSHIP OF 120-DAY POSTEXPOSURE CUMULATIVE SCORE TO DOSE-HEMATOLOGY-LEUCOCYTES

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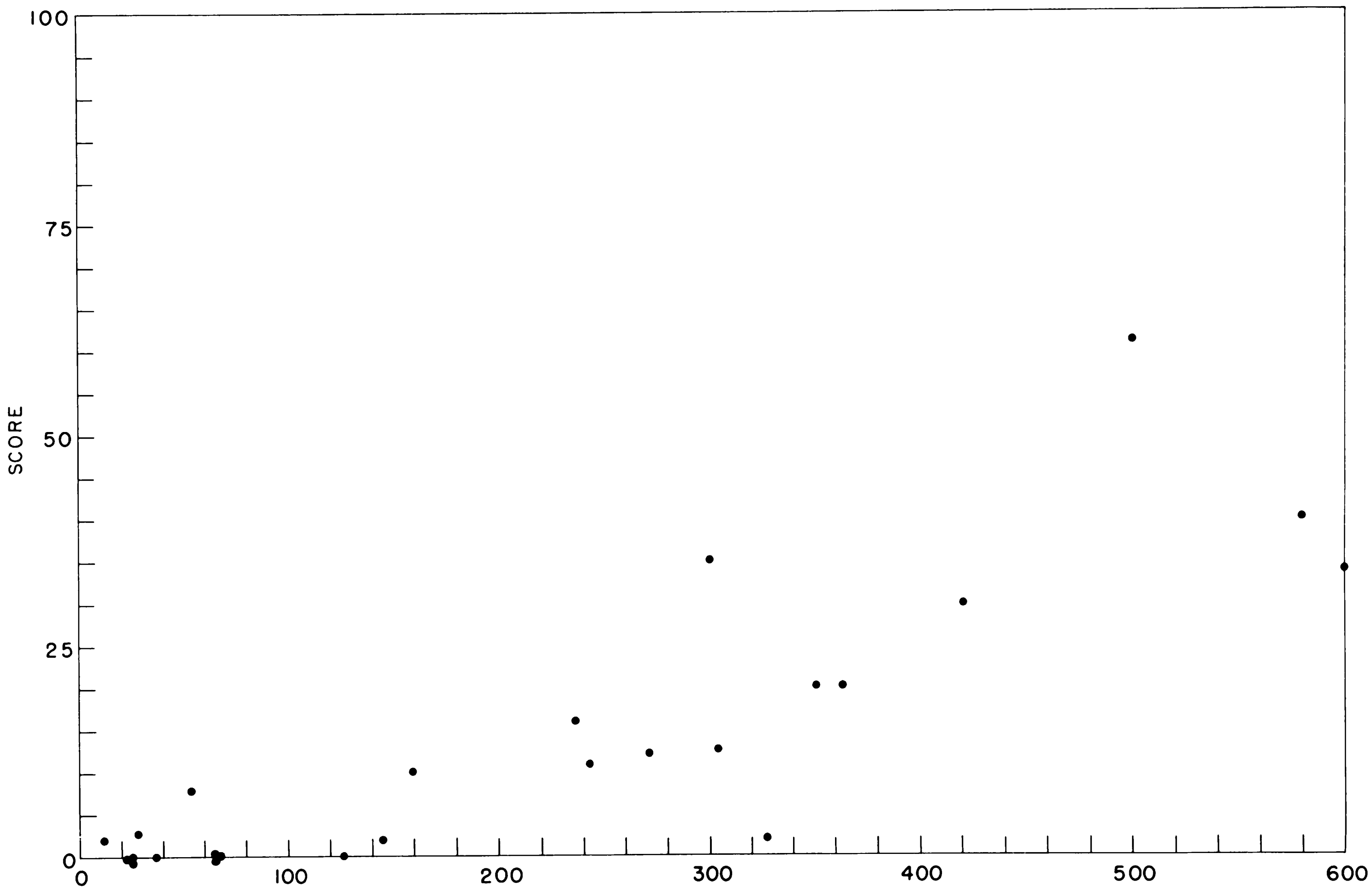

FIG. 14

RELATIONSHIP OF 120-DAY POSTEXPOSURE CUMULATIVE SCORE TO DOSE-HEMATOLOGY-LYMPHOCYTES

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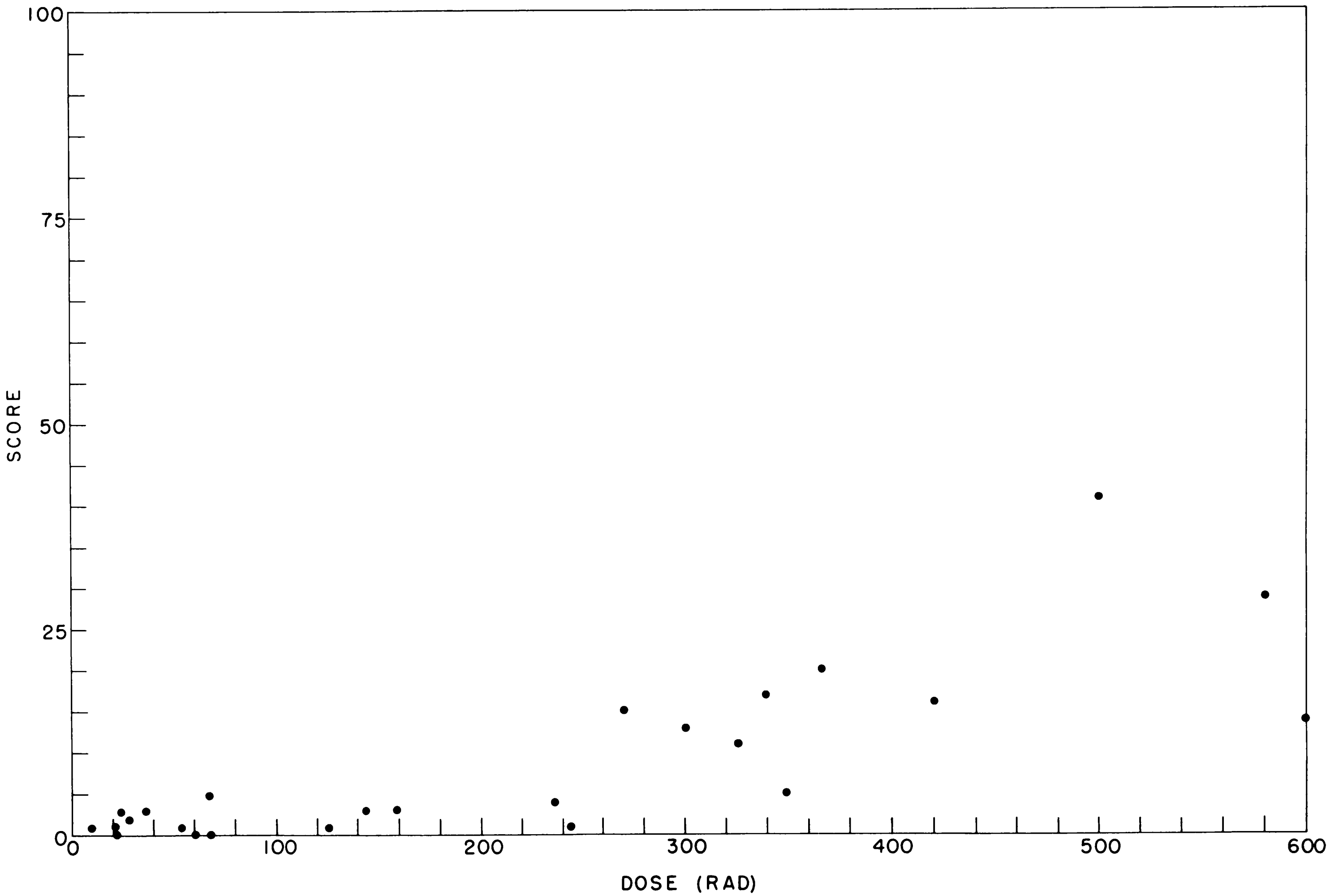

FIG. 15
RELATIONSHIP OF 120-DAY POSTEXPOSURE CUMULATIVE SCORE TO DOSE-
.HEMATOLOGY-NEUTROPHILS

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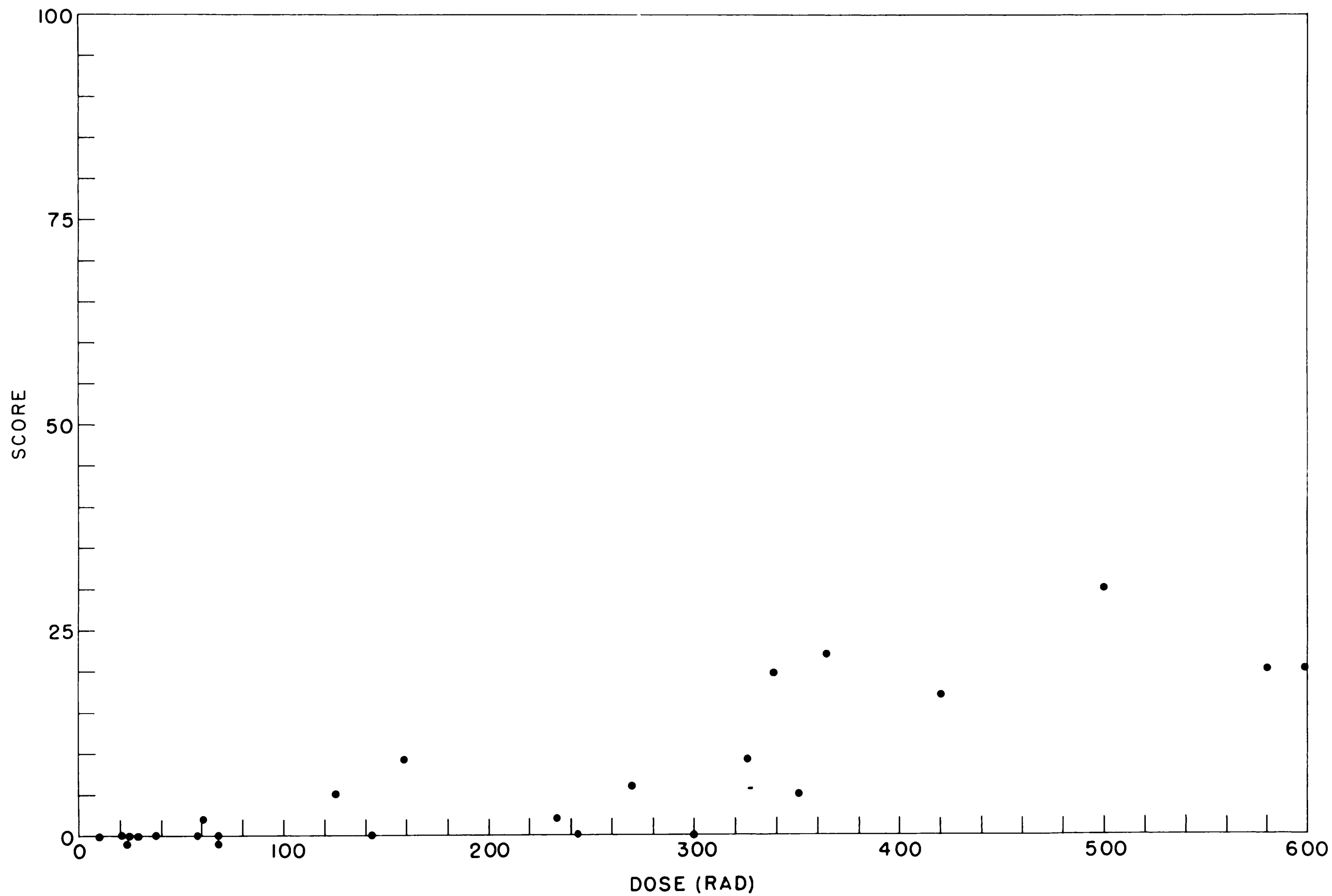

FIG. 16
RELATIONSHIP OF 120-DAY POSTEXPOSURE CUMULATIVE SCORE TO DOSE-
HEMATOLOGY-ERYTHROCYTES

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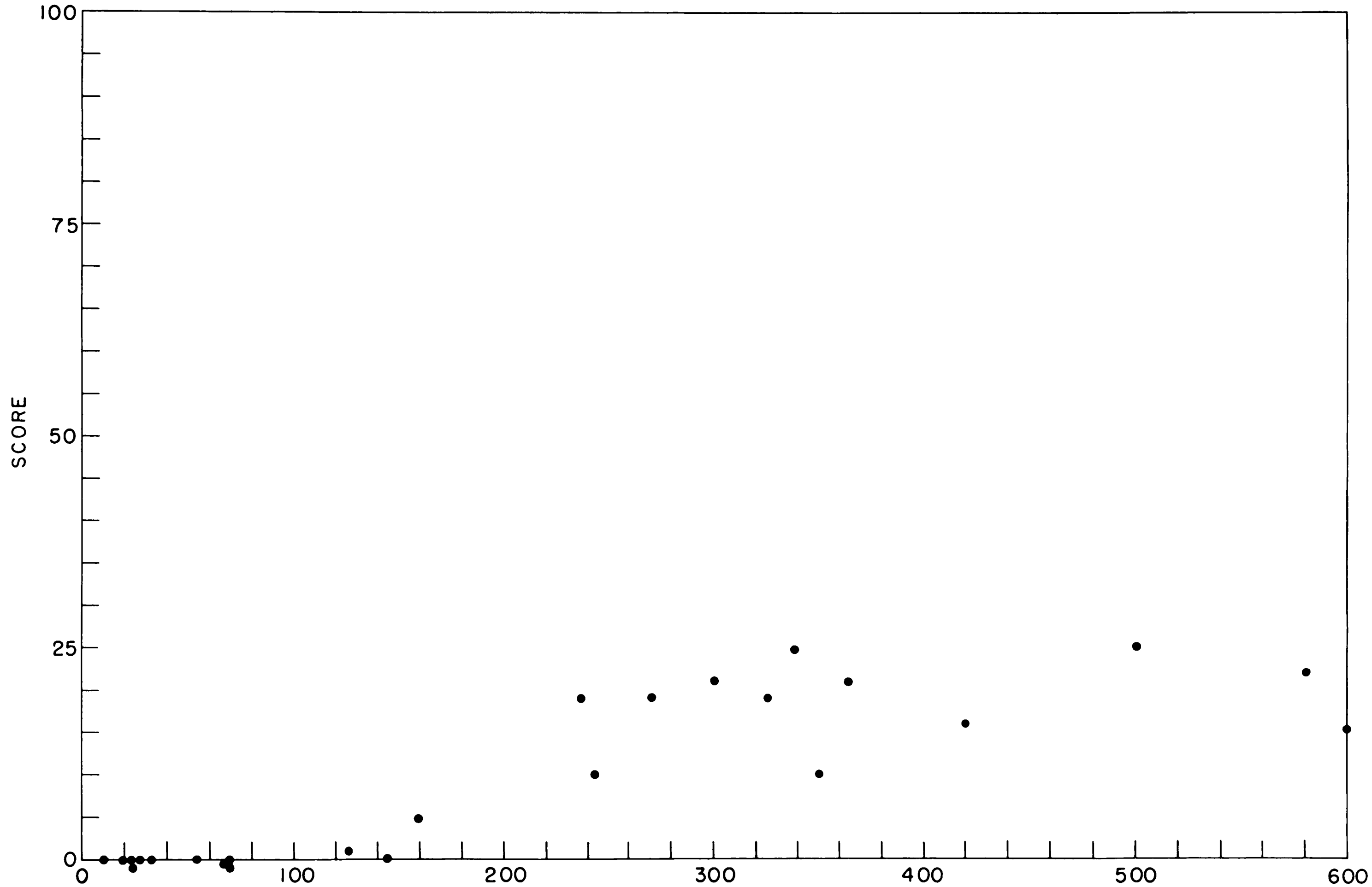

FIG. 17
RELATIONSHIP OF 120-DAY POSTEXPOSURE CUMULATIVE SCORE TO DOSE-
HEMATOLOGY-PLATELETS

respectively, as a function of dose.

On inspection of these figures, certain relationships are noted. In Fig. 12 the plotting of total score against dose indicates that 12 of the 25 cases which have a dose of less than 150 rads accumulated a score of ten or lower. The individual score bears no apparent relationship to dose at this low level of exposure. The 13 cases in which the exposure was to more than 150 rads appear to demonstrate a definite relationship between dose and cumulative score. A similar phenomenon appears in Fig. 13 which depicts the white count alone. The same pattern is discernable, though not as clearly, in Fig. 14, the lymphocyte graph. In Figs. 15 and 16 which present neutrophil and erythrocyte level relationships respectively, this pattern may still be seen, although now the break-point above which an effect is evident occurs at a higher dose. This is about 260 rads for the neutrophils and about 320 rads for the erythrocytes. The increase in score with increased dose is not as striking in these last two instances.

The platelet data, presented in Fig. 17, appear to show a somewhat different relationship. There is virtually no score at all for the cases under 150 rads. While the cases above that dose level do show a definite score accumulation, there is no perceptable relationship between increasing dose and the elevation of the platelet score.

Although the possibility of a threshold phenomenon seems conceivable, preliminary mathematical analysis of the data suggests that the response curve is best described by a quadratic function of the dose. This in turn might be taken to imply the possibility of a two-hit

mechanism for production of the hematologic derangements demonstrated by the data.

Caution must be observed about drawing such a conclusion in view of the complex series of biological alterations of injury and recovery separating the initial exposure from the cumulative quantitation of hematologic derangement over a 120-day period. Nevertheless, analysis of the 30-day cumulative injury scores produces a similar result. Also, a recent study by P. R. J. Burch[22] gives a similar dose-response pattern for radiation-related leukemia. Further analysis of these data is in progress and will be reported separately.

1.5 Summary

Certain general conclusions resulting from the foregoing review of previous accident medical data may be summarized at this point. It has been possible to classify individual radiation over-exposure accident patients in accordance with their overall clinical course and eventual outcome. These classifications have been called radiation injury groups. The early presence or absence of a few key clinical signs and symptoms has been shown to be related closely to the radiation injury group classification determined by consideration of the entire course. Various laboratory findings, particularly in the area of hematology, also have been shown to be related to the group classifications. A rather specific range of doses has been shown to be associated with each of the various clinical injury group classifications as well. The second section of this report will utilize the

relationships derived from the foregoing analysis to recommend clinical procedures which will aid in the management of future exposure cases and in the accumulation of further data which will augment our knowledge of the effects of human radiation overexposure.

2. RECOMMENDED MEDICAL PROCEDURES

2.1 Introduction

The selection and time of performance of appropriate diagnostic and clinical procedures will be strongly influenced by three kinds of knowledge. The first is the clinical acumen and judgment which would be brought to bear on the medical management of any patient. The second is an awareness of the underlying pathophysiology of the acute radiation syndrome in man. The third is a general idea of the magnitude and type of radiation to which the patient has been exposed. Discussion of the first of these is beyond the scope of this paper. The next two have already been discussed, but their application in the individual case warrants some further consideration.

In a given accident, the exposure dose would seem to be the logical piece of information which upon clinical management can be planned. As has already been indicated, however, it is not necessarily helpful in the individual case for two reasons: First, the dose, if it can be determined, is not usually available as soon as needed. Second. no one individual will necessarily respond exact as do others in a given dose category. Therefore, the highest priority is given to diagnostic recommendations in the early postexposure period which will accumulate sufficient information to establish the response "profile" of the individual under study in comparison with the responses of others who were studied in a similar manner. When this information is available, a reasonably accurate prognosis can be made and planning of clinical management can proceed even in the absence of dosimetry

information. It is highly desirable, of course, to obtain physical dosimetry data as soon as possible to supplement the clinical estimate of injury.

Subsequent tests will be recommended to serve four purposes: 1) to validate the original diagnostic and prognostic conclusions about the patient; 2) to detect promptly the development of clinical complications in the patient's course; 3) to provide additional data for improved profile scoring in future cases; and 4) to supply more information about radiation pathophysiology.

2.2 Diagnostic Procedures

Given one or several individuals who have accidentally received, in all probability, a significant acute injurious radiation overexposure of neutron and/or gamma-ray type, how should the attending physician proceed? It is disturbingly obvious that in our present state of knowledge of human radiation injury there really is no procedure which might not be productive of some new information of immediate or eventual applicability. However, it is also obvious that diagnostic tests must include those that are most essential and none that are detrimental to the individuals involved. The resultant limitation in number and frequency makes a well-informed selection all the more important.

In the course of this analysis of criticality accidents, certain diagnostic hints have emerged which may aid in dealing with similar situations in the future. Further experience may alter these

recommendations completely, but at this time the procedures listed in Table IX seem to be the most likely to facilitate preliminary clinical evaluation and subsequent management.

The diagnostic tests have been outlined in tabular form for convenience of the reader. Frequency and duration of test performances are given. Suggestions based on the analysis of previous studies are made for each of the five clinical injury groups. In line with the objectives of these diagnostic recommendations, test procedures have been categorized as Type A, B, or C. Type A procedures are of particular applicability in the early diagnostic and prognostic appraisal of clinical radiation injury. Type B procedures are of more help in confirming the earlier estimations of injury and in recognizing and managing the development of complications. Type C procedures are of possible but not yet verified value for future use in either of the two previous categories. In order to determine their suitability, they should be utilized when feasible.

Although the radioassay tests, such as determination of Na activation in urine, blood, and whole body following neutron exposure, are dosimetry tests performed by the Health Physicist rather than clinical laboratory procedures, they are mentioned in Table IX since their performance requires the cooperation and judgment of the physician. If at all possible, the accomplishment of these procedures should be encouraged since knowledge of the physical exposure dose is a most valuable supplement to the clinical injury estimate. It may allow for early identification of the hyperresponsive patient and

TABLE IX. RECOMMENDED DIAGNOSTIC PROCEDURES FOR CLINICAL MANAGEMENT OF RADIATION INJURY

	Group										
	I-II-III-IV			I	II			III		IV	V
Time (d)	1	2	3	STT	STT	18–48	STT	4–48	STT	4	1
Type A Procedures											
History											
Symptoms) onset	x	x	x	x	x	D	x	D	x	D	D
Signs) duration	x	x	x	x	x	D	x	D	x	D	D
Past Medical	x										
Physical Examination											
General						d 21	3 mo^{+}	d 15–30	6 mo^{+}	d 6	D
Body weight	x			x	x	D	x	D	x	D	D
Urinary output	x	x	x		x	D		D		D	6hr
Laboratory Tests											
Hematology											
Hematocrit	x	x	x	x	x	D	x	STT	x	D	6hr
Leucocytes	x	x	x	x	x	D	x	D	x	D	6hr
Differential Count	x	x	x	x	x	D	x	D	x	D	6hr
Calculation of Total Neut. and Lymph	x	x	x	x	x	D	x	D	x	D	6hr
Platelets	x	x	x	x	x	D	x	STT	x	D	6hr
Bone Marrow Aspiration				d 30	14 d	14 d	mo 6	14 d	mo 6	7 d	d 1
Radioassay											
Blood Na^{24}	x	x									
Whole Body Counting	x	x									
Type B Procedures											
Laboratory Tests											
Hematology											
Sedimentation Rate	x	x	x	x	x	D	x	D	x	D	6hr
Reticulocytes	x	x	x	x	x	D	x	STT	x	D	6hr
Bleeding) Clotting) Times	x					STT		STT	–75 d	3 d	6hr
Biochemistry											
Blood											
NPN	x	prn	prn					prn		STT	6hr
Sodium	x	prn	prn					prn		prn	d 1
Chloride	x	prn	prn					prn		prn	d 1
Potassium	x	prn	prn					prn		prn	d 1
pH or CO_2	x	prn	prn					prn		prn	d 1
Urine											
Routine analysis	x	x	x		x	D	x	D	x	D	6hr
Stool											
Occult blood	x					D		d 12^{+}		D	All
Opthalmology											
Slit lamp			x	6 mo^{+}			6 mo^{+}		6 mo^{+}		
Type C Procedures											
Biochemistry											
Serum bilirubin	x	x	x		x	STT		STT	–30 d	D	6hr
Urine BAIBA	x			–30 d	x	D		D		D	D

RECOMMENDED FREQUENCY OF TIME OF PERFORMANCE

STT = Standard Testing Times: 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 40, 44, 48, 60, 90, 105, 120 days; 6 months, 1 year, and annually.
x = at times indicated in column heading.
d = day(s).
D = daily during time indicated in column heading.
nD = frequency in days.
–Dn = up to and including day at times indicated in column heading.
Dn^{+} = on and after day at times indicated in column heading.
Dn = specific day recommended.
n = all time after day specified.
prn = as indicated by clinical course.

make clinical management easier thereby. Details of the dosimetry techniques are given in the companion section of this report, ORNL-2748, Part A.[16]

While this procedural outline is partitioned, somewhat arbitrarily, for the sake of clarity of presentation, it should be clearly understood that each individual case must be viewed and studied in its own right as the particular symptomatology and course require. It should also be recognized that it is beyond the purpose of the outline to include specific recommendations for future scientific lines of investigation of the acute radiation syndrome. Such radiobiological studies, while assuredly desirable, must emanate from the interest and availability of appropriate research personnel in each particular instance. For the purposes which have stimulated the preparation of this report it should suffice to point out that the accumulation of good basic clinical and laboratory data in a consistent and logical form in any future accidents will be a distinct contribution to radiobiological knowledge as well as a means of facilitating clinical patient management.

2.2.1 Preliminary Evaluation of Radiation Injury

An attempt has been made, utilizing the early clinical data recorded in past accidents, to identify those findings which have the greatest early prognostic value in indicating the correct injury group assignment and, thus, the subsequent clinical course. On this basis a procedural outline has been drawn up which should aid in

planning for subsequent patient care. It is briefly summarized in Fig. 18. This evaluation plan rests on the early and accurate performance of two familiar diagnostic procedures called for in Table IX — continuous, detailed, clinical observations including a complete history of the immediate episode as well as of previous and preexisting abnormalities in health. A complete physical examination is indicated both to find any abnormalities present and to serve as a base-line observation for subsequent changes. Items of particular interest are the exact time of onset and duration of symptoms and signs listed in Table IV. Central nervous system and gastrointestinal findings are of greatest importance in the preliminary evaluation process.

The blood counts should include erythrocyte count, or hemoglobin level, or hematocrit; leukocyte count; differential count; calculated total lymphocytes and neutrophils; and platelet count. They should be performed at least once daily for the first three days. To evaluate the results, the blood count profile scoring method is recommended.

2.2.2 Diagnostic Use of the Profile Scoring Method

To demonstrate the use of the scoring method, the hematological findings of Hypothetical Case 3 are presented in Table X. The leukocyte count on Day 1 is 13,000, giving a test score of 1. On Day 2, a count of 12,100 is found. While this test score again is 1, the cumulative leukocyte score is now 2. These steps are carried out for all components of the blood count.

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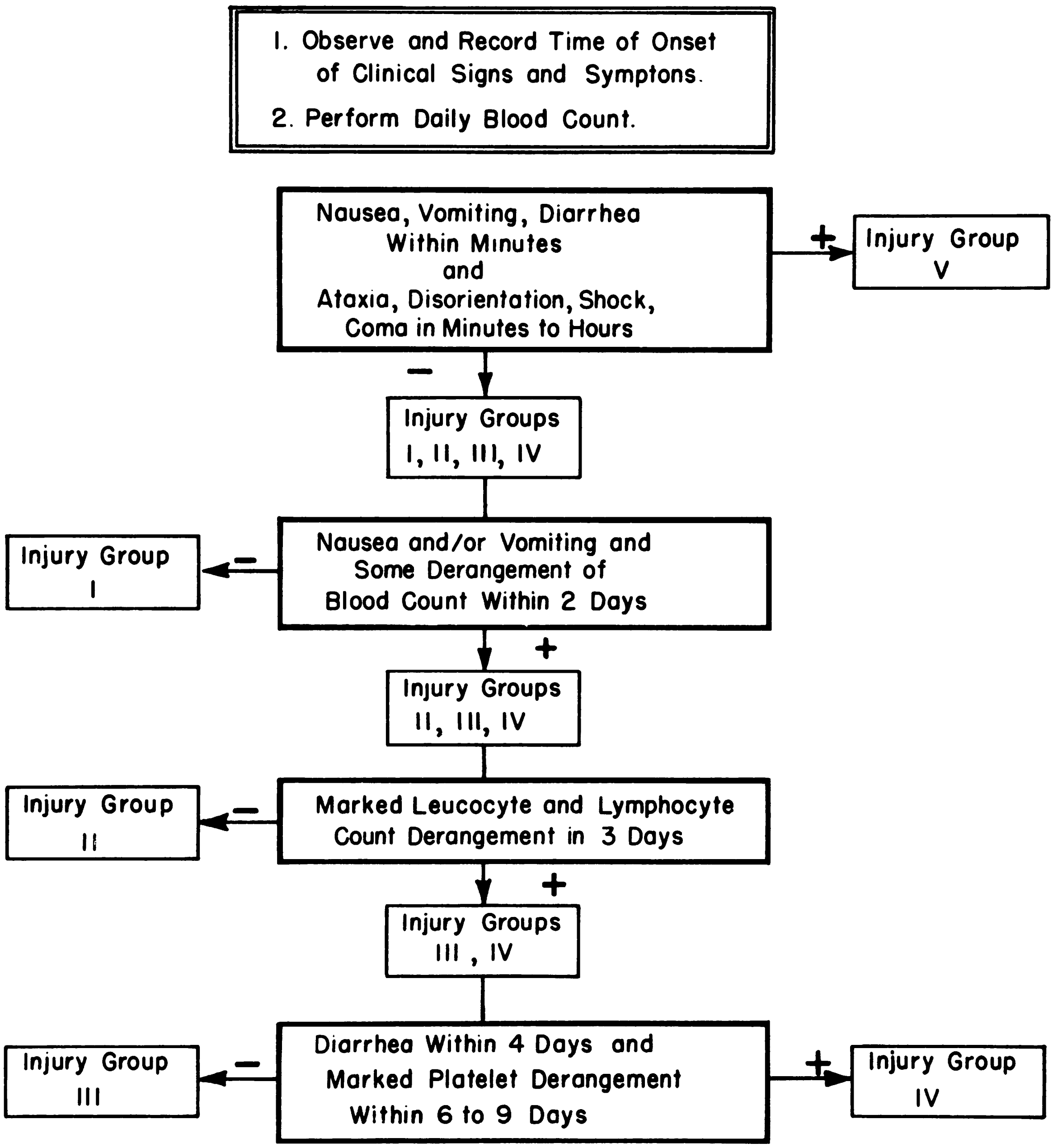

FIG. 18
PRELIMINARY EVALUATION OF RADIATION INJURY

Table X

Blood Counts and Profile Scoring—Hypothetical Case 3

Day	Hematocrit			Leucocytes			Neutrophils			Lymphocytes			Platelets			Total Score	
	Vol.%	Score		Count	Score		Count	Score		Count	Score		Count x 1000	Score			
		T	C		T	C		T	C		T	C		T	C	T	C
1	48	0	0	13,000	1	1	13,000	1	1	800	1	1	320	0	0	3	3
2	47	0	0	12,100	1	2	11,200	1	2	290	4	5	330	0	0	6	9
3	47	0	0	5,300	0	2	5,000	0	2	100	4	9	350	0	0	4	13
4	47			3,900			3,700			150							
5				2,900			2,550			280							
6	48	0	0	1,400	3	5	1,160	2	4	260	4	13	300	0	0	9	22
7				1,550			1,300			200							
8				1,600			1,350			180							
9	48	0	0	1,700	3	8	1,500	1	5	150	4	17	90	2	2	10	32
10				2,000			1,800			100							
11				2,050			1,950			90							
12	47	0	0	2,100	2	10	2,000	0	5	90	4	21	60	2	4	8	40
13				2,050			1,800			300							
14				1,950			1,500			400							
15	47	0	0	1,950	3	13	1,250	2	7	650	3	24	50	2	6	10	50
16				2,050			1,280			760							
17				2,150			1,300			820							
18	47	0	0	2,250	2	15	1,350	2	9	880	1	25	40	3	9	8	58
19				2,250			1,300			900			30				
20				2,150			1,200			920			20				
21	45	0	0	2,100	2	17	1,150	2	11	950	1	26	10	4	13	9	67
22				1,750			1,000			750			20				
23				1,300			700			600			30				
24	44	0	0	900	4	21	550	3	14	300	3	29	50	4	17	14	81
25				850			500			250			30				
26				800			550			200			20				
27	39	1	1	750	4	25	600	3	17	100	4	33	10	4	21	16	97
28	31			600			500			84			10				
29	32	2	3	500	4	29	400	4	21	75	4	37	10	4	25	18	115

T = test score; C = cumulative score

The test and cumulative scores of individual counts and total blood counts are then compared with those presented as group mean scores and their ranges in Appendix Table A-X. The total cumulative scores of Hypothetical Case 3 for Days 1, 2, and 3 are 3, 9, and 13. Since the mean scores of Group III are 1.6, 7.6, and 14.0, while those of Group II are 1.4, 2.4, and 3.3, it appears that Hypothetical Case 3 is most likely to present a rather severe version of the clinical course of Group III. Referring to Fig. 18, one also can narrow down this patient's injury pattern to that of Groups III or IV. Further clinical and blood count data are needed to make a more definite distinction between Groups III and IV. The amount of platelet derangement mentioned in Fig. 18 can be determined by looking at the appropriate space in Appendix Table A-X.

It should be pointed out that when more frequent counts are performed than the recommendations call for, the most abnormal one in the particular time period is used for scoring.

2.2.3 Subsequent Diagnostic Procedures

When the preliminary radiation injury group assignment of a given patient has been made, further diagnostic tests are designed to verify the assignment, to identify complications, and to aid in their management. Only a few Type B tests have been mentioned in Table X. These are not intended to exclude others, but are merely the ones which seemed the most useful in past cases and the ones for which early base-line values might be desired.

The few Type C procedures in Table X were used in some of the cases and seemed to be related to the extent of injury. Insufficient frequency of application prohibits any definite opinion about their value as yet. Of course, many other procedures may also prove to be applicable to this type of clinical problem.

2.3 Clinical Management

As in the case of diagnostic procedures, a consideration of the choice and results of past methods of therapy helps to shape the present recommendations. The types of agents employed in the accidents reported herein are listed in Table X. It will be seen that only in cases which fall into Group II or a higher one has specific treatment appeared necessary. In general, since the means for reversing the basic cellular mechanisms which underlie radiation effect are not yet at hand, the clinical approach has been, and should be conservative and supportive, with specific therapy being reserved for symptomatic indications.

As has already been indicated, it is desirable for all cases with a probability of significant acute injurious radiation overexposure to be hospitalized for close observation. The accomplishment of the preliminary estimation of clinical radiation injury as described in the preceding section on diagnostic procedures should indicate within 72 hours those cases falling into Group II or above. These should be continued as hospitalized patients. The others can be reassured of their benign prognosis and released from inpatient care when asymptomatic.

2.3.1 Recommendations for Injury Groups:

Group I. These patients can be followed as outpatients, using the previously suggested tests. There is no specific medical contra-indication to a return to work as soon as dosimetry, clinical symptoms and findings, and laboratory data have established the low level of overexposure. Considerations of public opinion, medicolegal sequelae and the like doubtless have played a role in the more conservative prescription of a rest period of varying length which has been utilized in several cases within Group I. It is definitely recommended that subsequent work should be in a capacity in which further radiation overexposure is unlikely.

Group II. Patients in this group will exhibit transient nausea and vomiting which will probably not require more than the adminis-tration of antiemetic agents, if that. There is no definite therapeutic procedure for radiation epilation other than reassurance concerning its probable impermanence.

Complications of the existing bone marrow damage such as anemia, infection and evidences of bleeding have been mild when present at all in Group II. It is, therefore, considered advisable to adopt a con-servative attitude of watchful waiting, with the means for vigorous and definitive treatment available if and when needed. Thus, blood and perhaps plasma transfusions, antibiotics and the like should be ready in reserve. An attempt to reduce the likelihood of infections by emphasis on personal hygiene and the use of aspectic isolation methods may well be warranted.

The mechanism of the observed weakness and fatigue of these patients is not clear and therefore no specific therapy can be recommended at this time. Rest is indicated until symptoms and major laboratory abnormalities subside. Future occupational radiation exposure should be avoided.

Group III. It is the therapeutic management of patients in Group III that presents the most challenging opportunity to alter an otherwise unfavorable prognosis. In this group one can expect to deal with the major complications of serious bone marrow damage, some gastrointestinal injury, and secondary renal and cardiovascular problems.

Prompt bed rest, bland diet, good nursing care and a realistic appraisal of the medical situation are indicated as soon as symptomatology hematological "profile", and dosimetry make classification in Group III apparent.

Antiemetics are indicated for severe and prolonged nauses and vomiting in the initial phase or later. Intravenous feeding may be necessary as well, to maintain fluid and caloric balance in the early stage or in the later phase when gastrointestinal symptoms may recur. The maintenance of acid-base and electrolyte balance should be attempted also, with frequent serum pH, acid-base, and electrolyte studies as a guide.

When increasingly severe depression of bone marrow function ensues toward the second and third weeks after exposure, certain precautions are indicated. To reduce infections, an effort to minimize bacterial exposure should be attempted utilizing isolation and aseptic

techniques in all contacts with the patients. Although prophylactic antibiotics have been employed in many instances, real proof of their value for this purpose is not too clear-cut. There are indications that such use has blunted their effectiveness in subsequent infections during the course. Bacteriocidal antibiotics in parenteral form should be reserved for therapeutic use in high dosage when infections of overt or even occult nature occur. These may be suggested by symptoms, by fever, or simply by a sharp rise in a previously low sedimentation rate, despite the absence of any resultant leucocytosis. Bacterial sensitivity studies should be performed if possible, and their results used as a therapeutic guide.

Hemorrhagic phenomena are difficult to treat by any conventional means. Platelet transfusions have been tried with no clear and lasting benefit resulting. This may be due to the fact that the platelets were not given promptly after collection. Anemia, which develops insidiously, will respond to conventional transfusion therapy. This should be used only when a clinically significant fall in red cell volume has developed.

A new form of therapy may be utilized to treat severe pancytopenia accompanied by distinct clinical sequelae, such as uncontrollable infection or bleeding, with a clearly grave prognosis. This is the performance of bone marrow transfusion using cells from a homologous donor, matching in sex, and in major, and most minor blood subgroups. The time for successful performance of this procedure had previously been considered to be limited to a few days after radiation exposure.

Now, the recent, apparently helpful use of such a procedure in the Yugoslav accident patients[12] about a month after exposure suggests that the decision concerning its use can await the unfolding of the clinical course. This delay removes the necessity to base such action on the preliminary physical dosimetry and early, fragmentary data concerning the extent of radiation injury.

Very little is known as yet about the utility or even desirability of bone marrow transfusion in man. In the treated Yugoslav patients, a prompt rise to a peak occurred in the level of granulocytes, platelets and reticulocytes before such improvement was found in a lower dose patient recovering spontaneously. Also, the pattern of platelet response was somewhat different. Furthermore, red cell agglutination tests indicated a phase of increase in the number of donor cells over a time period in which transfused cells should have been decreasing. However, it must be noted that the hematological improvement occurred at a time when recovery occurring spontaneously would have become evident. Thus, it cannot be stated with certainty that a true "take" of the marrow transplant developed. Instead the donor marrow may have served as a temporarily functioning bridge over the hiatus in the patients' blood formation process. What the overall value of the transplant procedure will be cannot yet be stated. It should be reserved as a desperate measure against overwhelming clinical odds until more data become available.

In the more seriously affected patients in Group III, occurrence of rather severe gastrointestinal symptomatology, including partial

intestinal obstruction, may take place. A bland diet in the acute illness phase may be helpful in minimizing such difficulties.

Group IV. The patients in this range exhibited a course similar to that of the more severely injured Group-III patients but telescoped into a shorter time period, and with a fatal outcome. Gastrointestinal difficulties require the major supportive therapeutic effort before hematological disturbances reach full fruition. Vigorous treatment including tubal gastrointestinal decompression, fluid replacement with correction of electrolyte and caloric deficits, the use of antiemetics, antihypotensive agents, antibiotics, and bone marrow transfusion are advocated in this situation.

Secondary cardiovascular and renal failure may further complicate this grave clinical state. Response to hemodialysis in one such instance was poor. Detailed biological data collection is particularly indicated in these difficult cases if present day therapeutic inadequacy is to be altered in the future.

Group V. The one case in this group showed the evidence of the experimentally anticipated central nervous system injury associated with very high radiation dose. Palliation of the accompanying hypotension and gastrointestinal symptoms was carried out. No specific recommendations are yet available for this situation, other than supportive therapy.

Late Sequelae: The only late sequelae of radiation overexposure in the accident cases reported herein has been the development of lenticular cataracts. There is no known prophylaxis against this

occurrence, but if the usual spontaneous regression of the radiation cataract is inadequate, the ordinary surgical procedure for its removal is satisfactory.

No other long term effects can be anticipated in any given case although the general statistical probability of leukemogenesis or genetic mutation may be slightly enhanced. There are no such findings reported in any of these cases.

2.4 Conclusion

The general medical findings in the radiation accident patients reviewed in this report are not novel. They correspond with those reported in a number of other situations in which humans have been exposed to significant whole-body radiation overexposure. However, these particular findings stem from the types of accidents which are of special interest to an increasing number of physicians now coming into contact with the fast-growing field of nuclear technology. For this reason, conclusions drawn from this series may be especially useful.

It is rather reassuring to find that, despite the disturbing physical complexity of nuclear criticality accidents, the key procedures for clinical evaluation of resultant injury are such familiar ones as a detailed medical history, thorough physical examinations, and accurate blood counts. The additional support provided by improvements in radiation dosimetry and modern clinical laboratory procedures is, of course, very helpful as well.

In the therapy of such patients also, good medical management, firmly based on an understanding of the pathophysiology of the acute radiation syndrome, does not really differ from the treatment of less modern maladies. The development of bone marrow transfusion as a possible specific form of treatment for this syndrome does provide, however, a somewhat specialized therapeutic procedure.

Concerning the relative value of physical dose measurements and biological signs of injury as aids in the care of human radiation over-exposure, the nature of the exposure incident is most important. What is suited to the triage of victims of a nuclear warfare catastrophe is not necessarily appropriate for the industrial accident victim. The utilization of precise clinical observations and frequent laboratory tests as advocated herein, with calculation of the injury profile score, may not be feasible under other circumstances. However, it is considered to be of particular value, especially when supplemented with good mixed radiation dosimetry, in medical management of the accidents of nuclear technology.

In summary, to disseminate current concepts about the diagnosis and management of a rare but increasingly frequent clinical entity, the acute radiation syndrome, all pertinent criticality accident cases have been reviewed. Circumstances; dosimetry; clinical signs, symptoms, and course; laboratory findings; and therapy are considered. On the basis of these data, recommendations for diagnosis and treatment are made to aid in clinical management, to facilitate the development of improved diagnostic procedures, and to increase the fund of biomedical data from which stems our understanding of human radiation injury.

3. OUTLINE AND SYNOPSIS OF ORNL-2748, PART A

3.1 Outline of ORNL-2748, Part A

Radiation Accidents: Dosimetric Aspects of Neutron and Gamma-Ray Exposures

G. S. Hurst and R. H. Ritchie, Editors

1. REVIEW OF PREVIOUS ACCIDENT DOSIMETRY DATA

    1.1 Introduction

    1.2 Los Alamos Accident LASL-I

    1.3 Los Alamos Accident LASL-II

    1.4 Argonne Cases

    1.5 U.S.S.R. Cases

    1.6 Oak Ridge Cases

    1.7 Yugoslavia Cases

    1.8 Los Alamos Accident LASL-III

2. RECOMMENDED DOSIMETRY SYSTEM

    2.1 General Description of the Dosimetry System

    2.2 Threshold Detector Techniques

    2.3 Blood Sodium Techniques

    2.4 Gamma Dosimetry with Chemical Techniques

    2.5 Glass Dosimetry

    2.6 Film Badge for Criticality Accident Applications

    2.7 Assignment of Individual Exposure Doses

3.2 Synopsis of ORNL-2748, Part A

As the outline indicates, ORNL-2748, Part A, deals with two main topics: (1) a systematic review of the dosimetry of previous nuclear accidents in which persons have been exposed to appreciable amounts of ionizing radiation, and (2) a recommended system of dosimetry which, when implemented, will lead to much more reliable and faster estimates of individual exposure doses.

The first collision tissue dose (neutrons and gamma rays separately in rad units) has been estimated for individuals exposed to ionizing radiations in the following major incidents: Los Alamos (1945), Los Alamos (1946), Argonne (1952), U.S.S.R. (before July 1956), Oak Ridge Y-12 Plant (1958), Yugoslavia (1958), and Los Alamos (1958). Wherever possible, individual neutron exposures were normalized on the basis of the ratio Na^{24}/Na^{23} in the individual's blood. The ratio together with knowledge of the incident neutron spectrum provides a basis for the determination of the first collision neutron dose for an individual. The first collision gamma dose was then estimated under the assumption that a gamma to neutron ratio may be uniquely assigned to a given set of exposure conditions.

The system of dosimetry recommended in Part A, when implemented, should eliminate the need for many of the assumptions which are necessarily introduced when the system is not used. For example, the neutron spectrum may be measured with a set of threshold detectors, and the ratio of gamma to neutron dose may be determined from the readings on chemical dosimeters and glass rods combined with threshold

detectors. As before, the assignment of individual exposure doses is based on the analysis of blood serum Na^{24}. A general description of the proposed system is followed by a detailed description of all the techniques needed to implement the system.

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APPENDIX

Table A-1

Summary of Laboratory Procedures Performed on Patients - Hematology

Procedure	Group							I							
	Pt.	LA2	LA6	LA7	LA8	LA9	LA10	LA12	A1	A2	A3	A4	OR6	OR7	OR8
Erythrocyte Count		X	X	X	X	X	X		X	X	X	X			
Hemoglobin		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Hematocrit			X					X					X	X	X
Leucocyte Count		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Differential		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Total Neutrophils		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Total Lymphocytes		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Total Eosinophils		X	X	X	X	X	X								
Total Basophils															
Total Manocytes		X	X	X	X	X	X								
Platelet Count		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Reticulucyte Count		X	X	X	X	X	X		X	X	X	X	X	X	X
Bilobed Lymphocytes									X	X	X	X	X	X	X
Acid Phosphatase Stain													X	X	X
Refractive Bodies (L)		X	X	X	X	X	X		X	X	X	X			
Fe^{59} Uptake (P)															
H^3 Thymidine													X	X	X
Sedimentation Rate			X										X	X	X
Bone Marrow Biopsy		X	X	X	X	X			X	X	X	X	X	X	X
B.M. Mitotic Index													X	X	X
Bleeding Time															
Coagulation Time			X	X	X	X	X								
P Prothrombin Time			X	X	X	X	X								
S Prothrombin Time															
Thromboplastin Generation															
Ac-Globulin															
Antihemophilic Globulin															
Fibrinogen															
Fibrinolysin															
Partial Thromboplastin Time															

X - Test performed one or more times.

Blank - Performance of test not reported.

Table A-1 (continued)

Summary of Laboratory Procedures Performed on Patients - Hematology

Procedure	Group II							
Pt.	LA4	R2	OR1	OR2	OR3	OR4	OR5	Y6
Erythrocyte Count	X	X						
Hemoglobin	X	X	X	X	X	X	X	X
Hematocrit	X		X	X	X	X	X	X
Leucocyte Count	X	X	X	X	X	X	X	
Differential	X	X	X	X	X	X	X	X
Total Neutrophils	X	X	X	X	X	X	X	X
Total Lymphocytes	X	X	X	X	X	X	X	X
Total Eosinophils	X							X
Total Basophils								
Total Monocytes	X							
Platelet Count	X	X	X	X	X	X	X	X
Reticulucyte Count	X	X	X	X	X	X	X	X
Bilobed Lymphocytes			X	X	X	X	X	
Acid Phosphatase Stain			X	X	X	X	X	
Refractive Bodies (L)	X							
Fe^{59} Uptake (P)								
H^3 Thymidine			X	X	X	X	X	
Sedimentation Rate	X	X	X	X	X	X	X	
Bone Marrow Biopsy	X	X	X	X	X	X	X	X
B.M. Mitotic Index			X	X	X	X	X	
Bleeding Time								
Coagulation Time	X		X	X	X	X	X	
P Prothrombin Time	X		X	X	X	X	X	
S Prothrombin Time			X	X	X	X	X	
Thromboplastin Generation			X	X	X	X	X	
Ac-Globulin			X	X	X	X	X	
Antihemophilic Globulin			X	X	X	X	X	
Fibrinogen			X	X	X	X	X	
Fibrinolysin			X	X	X	X	X	
Partial Thromboplastin Time			X	X	X	X	X	

Table A-1 (continued)

Summary of Laboratory Procedures Performed on Patients - Hematology

Procedure	Group: III						IV		V
Pt.	LA1	R1	Y2	Y3	Y4	Y5	LA3	Y1	LA11
Erythrocyte Count	X	X	X	X	X	X	X	X	
Hemoglobin	X	X	X	X	X	X	X	X	
Hematocrit									X
Leucocyte Count	X	X	X	X	X	X	X	X	X
Differential	X	X	X	X	X	X	X	X	X
Total Neutrophils	X	X	X	X	X	X	X	X	X
Total Lymphocytes	X	X	X	X	X	X	X	X	X
Total Eosinophils	X								
Total Basophils									
Total Monocytes	X						X		
Plate Count	X	X	X	X	X	X	X	X	X
Reticulucyte Count	X	X	X	X	X	X	X	X	
Bilobed Lymphocytes									
Acid Phosphatase Stain									
Refractive Bodies (L)	X						X		
Fe^{59} Uptake (P)									
H^3 Thymidine									
Sedimentation Rate	X	X							
Bone Marrow Biopsy		X	X	X	X	X	X	X	X
B.M. Mitotic Index									
Bleeding Time									
Coagulation Time							X		
P Prothrombin Time							X		
S Prothrombin Time									
Thromboplastin Generation									
Ac-Globulin									
Antihemophilic Globulin									
Fibrinogen									
Fibrinolysin									
Partial Thromboplastin Time									

Table A-II

Summary of Laboratory Procedures Performed on Patients - Biochemistry-Blood

Procedure	Group						I							
	Pt. - LA2	LA6	LA7	LA8	LA9	LA10	LA12	A1	A2	A3	A4	OR6	OR7	OR8
Sodium		X	X	X	X	X						X	X	X
Potassium												X	X	X
Chloride		X	X	X	X	X						X	X	X
CO_2												X	X	X
Calcium												X	X	X
Phosphorus												X	X	X
NPN												X	X	X
BUN		X	X	X	X	X								
Uric Acid		X	X	X	X	X						X	X	X
Creatanine														
Glucose												X	X	X
Protein-Total		X										X	X	X
A and G		X										X	X	X
Electrophoresis		X										X	X	X
Plasma α Amino N														
Alk. Phosphatase												X	X	X
Lactic Dehydrogenase												X	X	X
Transaminase (G.O.T.)												X	X	X
Transaminase (G.P.T.)												X	X	X
Cholesterol-Total												X	X	X
Esters												X	X	X
Icterus Index														
BSP				F										
Ceph.-Chol. Floc.	F	F	F											
Thymol Turbidity	F	F	F											
Benzoic Acid Excretion	F	F	F											

X - Test performed one or more times. F - Test performed only during follow-up period.
Blank - Performance of test not reported.

Table A-II (continued)

Summary of Laboratory Procedures Performed on Patients - Biochemistry-Blood

Procedure	Group	II						III							IV		V
	Pt. - LA4	R2	OR1	OR2	OR3	OR4	OR5	Y6	LA1	R1	Y2	Y3	Y4	Y5	LA3	Y1	LA11
Sodium	X		X	X	X	X	X	X			X	X	X	X	X	X	
Potassium			X	X	X	X	X	X			X	X	X	X		X	
Chloride	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	
CO_2			X	X	X	X	X										
Calcium			X	X	X	X	X								X		
Phosphorus			X	X	X	X	X	X			X	X	X	X		X	
NPN			X	X	X	X	X		X	X					X		X
BUN	X							X			X	X	X	X	X	X	
Uric Acid	X		X	X	X	X	X		X						X		X
Creatanine																	
Glucose			X	X	X	X	X										
Protein-Total	X	X	X	X	X	X	X	X							X		
A and G	X	X	X	X	X	X	X	X							X		
Electrophoresis			X	X	X	X	X	X							X		
Plasma α Amino N			X	X	X	X	X										
Alkaline Phosphatase			X	X	X	X	X										
Lactic Dehydrogenase			X	X	X	X	X										
Transaminase (G.O.T.)			X	X	X	X	X										
Transaminase (G.P.T.)			X	X	X	X	X										
Cholesterol-Total			X	X	X	X	X										
Esters			X	X	X	X	X										
Icterus Index															X		
BSP																	
Ceph.-Chol.Floc.								*			*	*	*	*		*	
Thymol Turbidity																	

* - Liver function tests were performed, but no specific tests are reported.

Table A-III

Summary of Laboratory Procedures Performed on Patients - Biochemistry-Urine

Procedure	Group							I							
	Pt.	LA2	LA6	LA7	LA8	LA9	LA10	LA12	A1	A2	A3	A4	OR6	OR7	OR8
Routine Analysis		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Measure 24 hr. Vol.		X	X	X	X	X	X		X	X	X	X	X	X	X
Total Nitrogen															
α Amino Nitrogen															
Uric Acid															
Amino Acids			X	X	X	X	X		X	X	X	X	X	X	X
BAIBA													X	X	X
Creatine															
Creatinine															
Potassium															
Chloride															
Phosphorus															
Urobilinogen			X	X	X	X	X								
Corprophorphyrin			X	X	X	X	X								
Corticoid Fractions			X	X	X	X	X								
PSP		F	F	F	F	F	F								

X - Test performed one or more times.
F - Test performed only during follow-up period.
Blank - Performance of test not reported.

Table A-III (continued)

Summary of Laboratory Procedures Performed on Patients - Biochemistry-Urine

Procedure	Group				II						III				IV		V
	Pt. LA4	R2	OR1	OR2	OR3	OR4	OR5	Y6	LA1	R1	Y2	Y3	Y4	Y5	LA3	Y1	LA11
Routine Analysis	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
Measure 24 hr. Vol.	X		X	X	X	X	X	X	X		X	X	X	X	X	X	X
Total Nitrogen			X	X	X	X	X	X			X	X	X	X		X	
α Amino Nitrogen			X	X	X	X	X										
Uric Acid			X	X	X	X	X										
Amino Acids	X		X	X	X	X	X	X	X		X	X	X	X	X	X	
BAIBA			X	X	X	X	X										
Creatine			X	X	X	X	X										
Creatinine			X	X	X	X	X										
Potassium	X																
Chloride								X			X	X	X	X		X	
Phosphorus								X			X	X	X	X		X	
Urobilinogen	X							X	X		X	X	X	X	X	X	
Corprophorphyrin	X								X						X		
Corticoid Fraction	X								X						X		
PSP	F																

Table A-IV

Summary of Laboratory Procedures Performed on Patients

Miscellaneous

Procedure	Group							I							
	Pt.	LA2	LA6	LA7	LA8	LA9	LA10	LA12	A1	A2	A3	A4	OR6	OR7	OR8
Blood Culture															
Throat Culture													X	X	X
Serum Bactericidal Activity													X	X	X
Stool Examination			X												
Stool Occult Blood			X	X			X								
Seminal Fluid Examination						X			X	X		X			
Testicular Biopsy															
Slit Lamp-Lenses		X	X		X				X	X	X	X			
Radioassay-Total Body															
Blood Na^{24}		X	X	X	X	X	X	X					X	X	X
Blood P^{32}		X	X	X	X	X	X								
Urine Na^{24}		X	X	X	X	X	X								
Urine P^{32}		X	X	X	X	X	X								

X - Test performed one or more times.
Blank - Performance of test not reported.

Table A-IV (continued)

Summary of Laboratory Procedures Performed on Patients

Miscellaneous

Procedure	Group					II						III				IV		V
	Pt.	LA4	R2	OR1	OR2	OR3	OR4	OR5	Y6	LA1	R1	Y2	Y3	Y4	Y5	LA3	Y1	LA11
Blood Culture											X					X		
Throat Culture				X	X	X	X	X								X		
Serum Bactericidal Activity				X	X	X	X	X										
Stool Examination										X						X		
Stool Occult Blood		X		X	X	X	X	X		X	X					X		
Seminal Fluid Examination		X							X				X	X	X		X	
Testicular Biopsy		X																
Slit Lamp-Lenses		X																
Radioassay-Total Body				X	X	X	X	X										
Blood Na^{24}		X		X	X	X	X	X	X	X		X	X	X	X	X	X	X
Blood P^{32}		X								X						X		
Urine Na^{24}		X								X						X		
Urine P^{32}		X								X						X		

Table A-V

Profile Values Assigned for Various Ranges of Abnormality

Hematology - Coagulation Tests

Test	Unit	Normal*	Increase or Decrease** (above or below)			
			1	2	3	4
Coagulation Time						
(Lee White) 1 Tube	min	6.5	10	15	20	25
(Lee White) 3 Tubes	min	12	20	25	30	35
Bleeding Time (Duke)	min	2.0	5	10	15	20
Clot Retraction (Diggs)	min	45	90	120	150	180
Tourniquet Test†	petechiae 5 cm diam	< 10	10	20	30	40
Plasma Prothrombin Time (Quick)	sec	12	14	18	25	40
	% normal††	100	65	30	16	10
Serum Prothrombin Consumption (2 stage)	%	100	90	70	50	30

* Only a unidirectional variation is possible or significant.

** Expressed as "universal mean" value. (See Ref. 19).

† Pressure maintained 8 min at midpoint between systolic and diastolic pressures of the individual.

†† Based on a 12 sec normal.

Table A-VI

Profile Values Assigned for Various Ranges of Abnormality

Biochemistry - Blood

Test	Units	Normal	Increase (above)				Decrease (below)			
			1	2	3	4	1	2	3	4
Sodium	mEq/L	136 - 145	148	152	156	160	130	128	124	120
Chloride	mEq/L	100 - 108	110	113	116	120	95	90	85	80
BUN	mg/100 cc	12 - 20	24	40	60	75				
NPN	mg N/100 cc	20 - 40	45	70	85	100				
Uric Acid	mg/100 cc	3.0 - 5.0	6.0	7.0	8.0	9.0				
Calcium	mg/100 cc	9.5 - 11.0	11.5	12.0	12.5	13.0	9.1	8.7	8.3	7.9
Bilirubin	mg/100 cc	0.2 - 0.5	1.	2	5	10				
Total Protein	gm/100 cc	5.9 - 8.0	8.4	8.8	9.2	9.6	5.5	5.1	4.8	4.4
Albumin	gm/100 cc	3.5 - 5.0	5.4	5.8	6.2	6.6	3.2	2.8	2.4	2.0
Globulin	gm/100 cc	1.5 - 3.2	3.5	3.8	4.1	4.4	1.3	1.0	0.7	0.4

Table A-VII

Profile Values Assigned for Various Ranges of Abnormality

Biochemistry-Urine

Test	Units	Normal	Increase* (above)			
			1	2	3	4
Coproporphyrin	µg %	4.9	10	15	20	30
	µg/day	30 - 100	140	180	230	300
Urobilinogen	mg/day	0 - 2	4	5	6	7

* Decrease of no significance.

Table A-VIII

Individual Profile Scores

Hematology-Peripheral Counts

LA1

DAY	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	0	0	1	1	2	2	1	1	0	0	4	4
2	0	0	1	2	2	4	3	4	0	0	6	10
3	0	0	1	3	2	6	4	8	0	0	7	17
6	0	0	2	5	3	9	3	11	0	0	8	25
9	0	0	0	5	1	10	4	15	2	2	7	32
12	0	0	0	5	0	10	4	19	2	4	6	38
15	0	0	0	5	1	11	2	21	2	6	5	43
18	0	0	0	5	1	12	1	22	0	6	2	45
21	0	0	1	6	1	13	1	23	2	8	5	50
24	0	0	4	10	4	17	3	26	2	10	13	63
27	0	0	3	13	3	20	4	30	2	12	12	75
30	X	X	X	X	X	X	X	X	X	X	X	X

ERY Erythrocytes (includes hemoglobin or hematocrit)

WBC Total leucocyte count

NEUT Absolute neutrophile count

LYMPH Absolute lymphocyte count

PLAT Platelet count

TOTAL Summation of all components

I Integral

C Cumulative

Table A-VIII (continued)

Individual Profile Scores

Hematology-Peripheral Counts

LA2

DAY	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	0	0	1	1	1	1	0	0	0	0	2	2
2	0	0	0	1	0	1	0	0	0	0	0	2
3	0	0	0	1	0	1	0	0	0	0	0	2
6	0	0	0	1	0	1	0	0	0	0	0	2
9	0	0	0	1	0	1	0	0	0	0	0	2
12	0	0	0	1	0	1	0	0	0	0	0	2
15	0	0	0	1	0	1	0	0	0	0	0	2
18	0	0	0	1	0	1	0	0	0	0	0	2
21	0	0	0	1	0	1	0	0	0	0	0	2
24	0	0	0	1	0	1	0	0	0	0	0	2
27	0	0	0	1	0	1	0	0	0	0	0	2
30	0	0	0	1	0	1	0	0	0	0	0	2
33	0	0	0	1	0	1	0	0	0	0	0	2
36	0	0	0	1	0	1	0	0	0	0	0	2
40	0	0	0	1	0	1	0	0	0	0	0	2
44	0	0	0	1	0	1	0	0	0	0	0	2
48	0	0	0	1	0	1	0	0	0	0	0	2
60	0	0	0	1	0	1	0	0	0	0	0	2
75	0	0	0	1	0	1	0	0	0	0	0	2
90	0	0	0	1	0	1	0	0	0	0	0	2
105	0	0	0	1	0	1	0	0	0	0	0	2
120	0	0	0	1	0	1	0	0	0	0	0	2

Table A-VIII (continued)

Individual Profile Scores

Hematology-Peripheral Counts

LA3

DAY	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	0	0	1	1	2	2	2	2	0	0	5	5
2	0	0	1	2	2	4	4	6	0	0	7	12
3	0	0	2	4	4	8	4	10	0	0	10	22
6	0	0	4	8	4	12	4	14	2	2	14	36
9	0	0	4	12	4	16	4	18	4	6	16	52
12	X	X	X	X	X	X	X	X	X	X	X	X

Table A-VIII (continued)

Individual Profile Scores

Hematology-Peripheral Counts

LA4

DAY	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	0	0	1	1	1	1	1	1	0	0	3	3
2	0	0	0	1	0	1	1	2	0	0	1	4
3	0	0	0	1	0	1	2	4	0	0	2	6
6	0	0	0	1	0	1	4	8	0	0	4	10
9	0	0	1	2	0	1	2	10	0	0	3	13
12	0	0	0	2	0	1	1	11	0	0	1	14
15	0	0	0	2	0	1	0	11	0	0	0	14
18	0	0	0	2	0	1	0	11	0	0	0	14
21	0	0	1	3	0	1	0	11	2	2	3	17
24	0	0	1	4	0	1	0	11	2	4	3	20
27	0	0	1	5	0	1	0	11	2	6	3	23
30	0	0	1	6	0	1	0	11	1	7	2	25
33	0	0	1	7	0	1	0	11	1	8	2	27
36	0	0	1	8	0	1	0	11	1	9	2	29
40	0	0	1	9	0	1	0	11	1	10	2	31
44	0	0	0	9	0	1	0	11	0	10	0	31
48	0	0	0	9	0	1	0	11	0	10	0	31
60	0	0	0	9	0	1	0	11	0	10	0	31
75	0	0	0	9	0	1	0	11	0	10	0	31
90	0	0	0	9	0	1	0	11	0	10	0	31
105	0	0	0	9	0	1	0	11	0	10	0	31
120	0	0	0	9	0	1	0	11	0	10	0	31

Table A-VIII (continued)

Individual Profile Scores

Hematology-Peripheral Counts

A3

DAY	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0
27	1	1	0	0	0	0	0	0	0	0	1	1
30	1	2	0	0	0	0	0	0	0	0	1	2
33	0	2	0	0	0	0	0	0	0	0	0	2
36	0	2	0	0	0	0	0	0	0	0	0	2
40	0	2	0	0	0	0	0	0	0	0	0	2
44	0	2	0	0	0	0	0	0	0	0	0	2
48	0	2	0	0	0	0	0	0	0	0	0	2
60	0	2	0	0	0	0	0	0	0	0	0	2
75	0	2	0	0	0	0	0	0	0	0	0	2
90	0	2	0	0	0	0	0	0	0	0	0	2
105	0	2	0	0	0	0	0	0	0	0	0	2
120	0	2	0	0	0	0	0	0	0	0	0	2

Table A-VIII (continued)

Individual Profile Scores

Hematology-Peripheral Counts

LA7

DAY	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	0	0	0	0	1	1	1	1	0	0	2	2
2	0	0	0	0	0	1	0	1	0	0	0	2
3	0	0	0	0	0	1	0	1	0	0	0	2
6	0	0	0	0	0	1	1	2	0	0	1	3
9	0	0	0	0	0	1	0	2	0	0	0	3
12	0	0	0	0	0	1	0	2	0	0	0	3
15	0	0	0	0	0	1	1	3	0	0	1	4
18	0	0	0	0	0	1	1	4	0	0	1	5
21	0	0	0	0	0	1	1	5	0	0	1	6
24	0	0	0	0	0	1	1	6	0	0	1	7
27	0	0	0	0	0	1	0	6	0	0	0	7
30	0	0	0	0	0	1	0	6	0	0	0	7
33	0	0	0	0	0	1	0	6	0	0	0	7
36	0	0	0	0	0	1	0	6	0	0	0	7
40	0	0	0	0	0	1	0	6	0	0	0	7
44	0	0	0	0	0	1	0	6	0	0	0	7
48	0	0	0	0	0	1	0	6	0	0	0	7
60	0	0	0	0	0	1	1	7	0	0	1	8
75	0	0	0	0	0	1	1	8	0	0	1	9
90	0	0	0	0	0	1	0	8	0	0	0	9
105	0	0	0	0	0	1	0	8	0	0	0	9
120	0	0	0	0	0	1	0	8	0	0	0	9

Table A-VIII (continued)

Individual Profile Scores
Hematology-Peripheral Counts

A2

DAY	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	0	0	1	1	1	1	0	0	0	0	2	2
2	0	0	0	1	0	1	0	0	0	0	0	2
3	0	0	0	1	0	1	0	0	0	0	0	2
6	0	0	0	1	0	1	0	0	0	0	0	2
9	0	0	0	1	0	1	0	0	0	0	0	2
12	0	0	0	1	0	1	0	0	0	0	0	2
15	0	0	0	1	0	1	0	0	0	0	0	2
18	1	1	0	1	0	1	0	0	0	0	1	3
21	1	2	0	1	0	1	0	0	0	0	1	4
24	1	3	0	1	0	1	0	0	0	0	1	5
27	1	4	0	1	0	1	0	0	1	1	2	7
30	1	5	0	1	0	1	0	0	0	1	1	8
33	0	5	0	1	0	1	0	0	0	1	0	8
36	0	5	0	1	0	1	0	0	0	1	0	8
40	0	5	0	1	0	1	0	0	0	1	0	8
44	0	5	0	1	0	1	0	0	0	1	0	8
48	0	5	0	1	0	1	0	0	0	1	0	8
60	0	5	0	1	0	1	0	0	0	1	0	8
75	0	5	0	1	0	1	0	0	0	1	0	8
90	0	5	0	1	0	1	0	0	0	1	0	8
105	0	5	0	1	0	1	0	0	0	1	0	8
120	0	5	0	1	0	1	0	0	0	1	0	8

Table A-VIII (continued)

Individual Profile Scores

Hematology-Peripheral Counts

A3

DAY	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0
27	1	1	0	0	0	0	0	0	0	0	1	1
30	1	2	0	0	0	0	0	0	0	0	1	2
33	0	2	0	0	0	0	0	0	0	0	0	2
36	0	2	0	0	0	0	0	0	0	0	0	2
40	0	2	0	0	0	0	0	0	0	0	0	2
44	0	2	0	0	0	0	0	0	0	0	0	2
48	0	2	0	0	0	0	0	0	0	0	0	2
60	0	2	0	0	0	0	0	0	0	0	0	2
75	0	2	0	0	0	0	0	0	0	0	0	2
90	0	2	0	0	0	0	0	0	0	0	0	2
105	0	2	0	0	0	0	0	0	0	0	0	2
120	0	2	0	0	0	0	0	0	0	0	0	2

Table A-VIII (continued)

Individual Profile Scores
Hematology-Peripheral Counts

R2

DAY	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	0	0	0	0	0	0	2	2	0	0	2	2
2	0	0	0	0	0	0	2	4	0	0	2	4
3	0	0	0	0	0	0	2	6	0	0	2	6
6	0	0	0	0	0	0	2	8	0	0	2	8
9	0	0	0	0	0	0	2	10	0	0	2	10
12	0	0	0	0	0	0	2	12	0	0	2	12
15	0	0	1	1	0	0	3	15	0	0	4	16
18	0	0	1	2	0	0	3	18	0	0	4	20
21	0	0	0	2	0	0	3	21	1	1	4	24
24	0	0	1	3	0	0	0	21	1	2	2	26
27	0	0	1	4	0	0	2	23	2	4	5	31
30	0	0	1	5	0	0	2	25	2	6	5	36
33	0	0	3	8	3	3	2	27	4	10	12	48
36	0	0	3	11	3	6	2	29	3	13	11	59
40	0	0	3	14	3	9	2	31	3	16	11	70
44	0	0	2	16	2	11	2	33	2	18	8	78
48	0	0	2	18	2	13	2	35	2	20	8	86
60	0	0	0	18	0	13	0	35	1	21	1	87
75	0	0	0	18	0	13	0	35	0	21	0	87
90	0	0	0	18	0	13	0	35	0	21	0	87
105	0	0	0	18	0	13	0	35	0	21	0	87
120	0	0	0	18	0	13	0	35	0	21	0	87

Table A-VIII (continued)

Individual Profile Scores
Hematology-Peripheral Counts

A4

DAY	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	0	0	1	1	1	1	1	1	0	0	3	3
2	0	0	0	1	0	1	1	2	0	0	1	4
3	0	0	0	1	0	1	0	2	0	0	0	4
6	0	0	0	1	0	1	0	2	0	0	0	4
9	0	0	0	1	0	1	0	2	0	0	0	4
12	0	0	0	1	0	1	0	2	0	0	0	4
15	0	0	0	1	0	1	0	2	0	0	0	4
18	0	0	0	1	0	1	0	2	0	0	0	4
21	0	0	0	1	0	1	0	2	0	0	0	4
24	0	0	0	1	0	1	0	2	0	0	0	4
27	0	0	0	1	0	1	0	2	0	0	0	4
30	0	0	0	1	0	1	0	2	0	0	0	4
33	0	0	0	1	0	1	0	2	0	0	0	4
36	0	0	0	1	0	1	0	2	0	0	0	4
40	0	0	0	1	0	1	0	2	0	0	0	4
44	0	0	0	1	0	1	0	2	0	0	0	4
48	0	0	0	1	0	1	0	2	0	0	0	4
60	0	0	0	1	0	1	0	2	0	0	0	4
75	0	0	0	1	0	1	0	2	0	0	0	4
90	0	0	0	1	0	1	0	2	0	0	0	4
105	0	0	0	1	0	1	0	2	0	0	0	4
120	0	0	0	1	0	1	0	2	0	0	0	4

Table A-VIII (continued)

Individual Profile Scores

Hematology-Peripheral Counts

<u>OR1</u>

Day	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	1	1	0	0	1	1
3	0	0	0	0	0	0	2	3	0	0	2	3
6	0	0	0	0	0	0	3	6	0	0	3	6
9	1	1	2	2	0	0	2	8	0	0	5	11
12	0	1	2	4	0	0	2	10	0	0	4	15
15	0	1	2	6	0	0	2	12	0	0	4	19
18	1	2	1	7	0	0	1	13	2	2	5	24
21	1	3	1	8	0	0	2	15	2	4	6	30
24	1	4	2	10	0	0	2	17	4	8	9	39
27	2	6	3	13	4	4	1	18	4	12	14	53
30	0	6	4	17	4	8	1	19	4	16	13	66
33	3	9	3	20	4	12	1	20	3	19	14	80
36	3	12	3	23	4	16	0	20	2	21	12	92
40	3	15	2	25	3	19	0	20	0	21	8	100
44	3	18	2	27	1	20	0	20	0	21	6	106
48	2	20	0	27	0	20	0	20	0	21	2	108
60	1	21	0	27	0	20	0	20	0	21	1	109
75	1	22	0	27	0	20	0	20	0	21	1	110
90	0	22	0	27	0	20	0	20	0	21	0	110
105	0	22	0	27	0	20	0	20	0	21	0	110
120	0	22	0	27	0	20	0	20	0	21	0	110

Table A-VIII (continued)

Individual Profile Scores

Hematology-Peripheral Counts

OR2

DAY	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	0	0	1	1	1	1	0	0	0	0	2	2
2	0	0	0	1	0	1	0	0	0	0	0	2
3	0	0	0	1	0	1	0	0	0	0	0	2
6	0	0	0	1	0	1	0	0	0	0	0	2
9	0	0	0	1	0	1	1	1	0	0	1	3
12	0	0	0	1	0	1	1	2	0	0	1	4
15	0	0	0	1	0	1	1	3	0	0	1	5
18	0	0	0	1	0	1	1	4	1	1	2	7
21	1	1	1	2	0	1	2	6	3	4	7	14
24	1	2	2	4	2	3	1	7	4	8	10	24
27	0	2	3	7	4	7	0	7	4	12	11	35
30	1	3	4	11	4	11	2	9	4	16	15	50
33	2	5	3	14	3	14	2	11	4	20	14	64
36	2	7	3	17	3	17	2	13	3	23	13	77
40	2	9	1	18	0	17	0	13	2	25	5	82
44	2	11	0	18	0	17	0	13	0	25	2	84
48	2	13	0	18	0	17	0	13	0	25	2	86
60	2	15	0	18	0	17	0	13	0	25	2	88
75	2	17	0	18	0	17	0	13	0	25	2	90
90	2	19	0	18	0	17	0	13	0	25	2	92
105	1	20	0	18	0	17	0	13	0	25	1	93
120	0	20	0	18	0	17	0	13	0	25	0	93

Table A-VIII (continued)

Individual Profile Scores

Hematology-Peripheral Counts

OR3

DAY	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	0	0	0	0	0	0	1	1	0	0	1	1
2	0	0	0	0	0	0	0	1	0	0	0	1
3	0	0	0	0	0	0	0	1	0	0	0	1
6	0	0	1	1	0	0	1	2	0	0	2	3
9	0	0	2	3	1	1	0	2	0	0	3	6
12	0	0	2	5	1	2	0	2	1	1	4	10
15	0	0	1	6	0	2	0	2	1	2	2	12
18	0	0	0	6	0	2	0	2	2	4	2	14
21	1	1	1	7	0	2	0	2	2	6	4	18
24	1	2	0	7	0	2	0	2	3	9	4	22
27	0	2	1	8	0	2	0	2	3	12	4	26
30	0	2	2	10	2	4	0	2	3	15	7	33
33	1	3	2	12	1	5	0	2	3	18	7	40
36	1	4	2	14	2	7	0	2	1	19	6	46
40	1	5	2	16	2	9	0	2	0	19	5	51
44	1	6	1	17	1	10	0	2	0	19	3	54
48	1	7	1	18	1	11	0	2	0	19	3	57
60	1	8	0	18	0	11	0	2	0	19	1	58
75	1	9	0	18	0	11	0	2	0	19	1	59
90	0	9	0	18	0	11	0	2	0	19	0	59
105	0	9	0	18	0	11	0	2	0	19	0	59
120	0	9	0	18	0	11	0	2	0	19	0	59

Table A-VIII (continued)

Individual Profile Scores

Hematology-Peripheral Counts

OR4

DAY	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	0	0	0	0	0	0	2	2	0	0	2	2
2	0	0	0	0	0	0	2	4	0	0	2	4
3	0	0	0	0	0	0	0	4	0	0	0	4
6	0	0	1	1	0	0	2	6	0	0	3	7
9	0	0	0	1	0	0	0	6	0	0	0	7
12	0	0	1	2	0	0	0	6	1	1	2	9
15	0	0	0	2	0	0	0	6	0	1	0	9
18	0	0	1	3	0	0	0	6	1	2	2	11
21	1	1	1	4	0	0	2	8	2	4	6	17
24	1	2	2	6	1	1	2	10	3	7	9	26
27	0	2	3	9	1	2	1	11	3	10	8	34
30	0	2	3	12	3	5	0	11	3	13	9	43
33	0	2	3	15	3	8	1	12	3	16	10	53
36	0	2	3	18	3	11	0	12	2	18	8	61
40	1	3	2	20	2	13	0	12	1	19	6	67
44	1	4	2	22	1	14	0	12	0	19	4	71
48	0	4	1	23	1	15	0	12	0	19	2	73
60	1	5	1	24	0	15	0	12	0	19	2	75
75	1	6	0	24	0	15	0	12	0	19	1	76
90	0	6	0	24	0	15	0	12	0	19	0	76
105	0	6	0	24	0	15	0	12	0	19	0	76
120	0	6	0	24	0	15	0	12	0	19	0	76

Table A-VIII (continued)

Individual Profile Scores
Hematology-Peripheral Counts

OR5

DAY	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	0	0	0	0	0	0	1	1	0	0	1	1
2	0	0	0	0	0	0	1	2	0	0	1	2
3	0	0	0	0	0	0	0	2	0	0	0	2
6	0	0	2	2	0	0	1	3	0	0	3	5
9	0	0	1	3	0	0	1	4	0	0	2	7
12	0	0	1	4	0	0	1	5	0	0	2	9
15	0	0	1	5	0	0	0	5	0	0	1	10
18	0	0	1	6	0	0	0	5	1	1	2	12
21	0	0	2	8	0	0	1	6	2	3	5	17
24	0	0	1	9	0	0	2	8	3	6	6	23
27	0	0	1	10	0	0	1	9	4	10	6	29
30	1	1	2	12	0	0	1	10	3	13	7	36
33	0	1	2	14	1	1	2	12	3	16	8	44
36	0	1	2	16	1	2	1	13	2	18	6	50
40	0	1	2	18	1	3	0	13	1	19	4	54
44	1	2	2	20	1	4	1	14	0	19	5	59
48	0	2	1	21	0	4	0	14	0	19	1	60
60	0	2	0	21	0	4	2	16	0	19	2	62
75	0	2	0	21	0	4	0	16	0	19	0	62
90	0	2	0	21	0	4	0	16	0	19	0	62
105	0	2	0	21	0	4	0	16	0	19	0	62
120	0	2	0	21	0	4	0	16	0	19	0	62

Table A-VIII (continued)

Individual Profile Scores

Hematology-Peripheral Counts

OR6

DAY	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	2	2	2	2	0	0	0	0	4	4
9	0	0	0	2	0	2	0	0	0	0	0	4
12	0	0	1	3	1	3	0	0	0	0	2	6
15	0	0	0	3	0	3	0	0	0	0	0	6
18	0	0	0	3	0	3	0	0	0	0	0	6
21	0	0	0	3	0	3	0	0	0	0	0	6
24	0	0	1	4	1	4	0	0	0	0	2	8
27	0	0	1	5	1	5	0	0	0	0	2	10
30	0	0	0	5	0	5	0	0	0	0	0	10
33	0	0	0	5	0	5	0	0	0	0	0	10
36	0	0	0	5	0	5	0	0	0	0	0	10
40	0	0	0	5	0	5	0	0	0	0	0	10
44	0	0	0	5	0	5	0	0	0	0	0	10
48	0	0	0	5	0	5	0	0	0	0	0	10
60	0	0	0	5	0	5	0	0	0	0	0	10
75	0	0	0	5	0	5	0	0	0	0	0	10
90	0	0	0	5	0	5	0	0	0	0	0	10
105	0	0	0	5	0	5	0	0	0	0	0	10
120	0	0	0	5	0	5	0	0	0	0	0	10

Table A-VIII (continued)

Individual Profile Scores
Hematology-Peripheral Counts

OR7

DAY	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
105	0	0	0	0	0	0	0	0	0	0	0	0
120	0	0	0	0	0	0	0	0	0	0	0	0

Table A-VIII (continued)

Individual Profile Scores

Hematology-Peripheral Counts

OR8

DAY	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
105	0	0	0	0	0	0	0	0	0	0	0	0
120	0	0	0	0	0	0	0	0	0	0	0	0

Table A-VIII (continued)

Individual Profile Scores

Hematology-Peripheral Counts

Y1

Day	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	1	1	0	0	0	0	0	0	0	0	1	1
2												
3	0	1	1	3	0	0	4	4	0	0	5	6
6	0	1	2	6	0	0	4	8	2	2	8	14
9	0	1	3	10	3	3	3	11	2	4	11	25
12	0	1	4	12	3	6	4	15	3	7	14	39
15	0	1	2	15	0	6	4	19	3	10	9	48
18	1	2	3	19	1	7	3	22	4	14	12	60
21	1	3	4	22	4	11	3	25	4	18	16	76
24	1	4	3	26	3	14	1	26	4	22	12	88
27	1	5	4	27	4	18	4	30	3	25	16	104
30	1	6	1		0	18	4	34	0	25	6	110

Table A-VIII (continued)

Individual Profile Scores

Hematology-Peripheral Counts

Y2

Day	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	1	1	0	0	0	0	0	0			1	1
2												
3	1	2	3	3	1	1	4	4			9	10
6	1	3	3	6	1	2	4	8			9	19
9	1	4	3	9	1	3	3	11	0	0	8	27
12	1	5	4	13	4	7	2	13	0	0	11	38
15	1	6	3	16	1	8	3	16	1	1	9	47
18	1	7	3	19	2	10	1	17	2	3	9	56
21	1	8	3	22	1	11	4	21	2	5	11	67
24	2	10	3	25	2	13	3	24	2	7	12	79
27	2	12	4	29	4	17	4	28	4	11	18	97
30	2	14	4	33	4	21	4	32	2	13	16	113
33	2	16	4	37	4	25	4	36	3	16	17	130
36	2	18	4	41	4	29	4	40	2	18	16	146
40	2	20	4	45	4	33	4	44	2	20	16	162
44	2	22	4	49	3	36	3	47	2	22	14	176
48	2	24	3	52	2	38	1	48	1	23	9	185
60	2	26	3	55	2	40	3	51	0	23	10	195
75	1	27	1	56	0	40	1	52	0	23	3	198
90	1	28	2	58	0	40	2	54	1	24	6	204
105	1	29	2	60	0	40	4	58	0	24	7	211
120	1	30	2	62	1	41	3	61	1	25	8	219

Table A-VIII (continued)

Individual Profile Scores

Hematology-Peripheral Counts

Y3

Day	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	1	1	0	0	0	0	0	0			1	1
2												
3	0	1	2	2	0	0	3	3			5	6
6	0	1	2	4	0	0	3	6	2	2	7	13
9	0	1	2	6	1	1	2	8	1	3	6	19
12	1	2	3	9	2	3	1	9	0	3	7	26
15	1	3	3	12	2	5	1	10	2	5	9	35
18	1	4	3	15	3	8	4	14	2	7	13	48
21	1	5	3	18	3	11	2	16	3	10	12	60
24	1	6	4	22	4	15	4	20	4	14	17	77
27	2	8	4	26	4	19	4	24	3	17	17	94
30	2	10	4	30	4	23	4	28	3	20	17	111
33	2	12	3	33	3	26	0	28	2	22	10	121
36	2	14	3	36	2	28	3	31	0	22	10	131
40	1	15	2	38	1	29	1	32	0	22	5	136
44	2	17	1	39	0	29	0	32	0	22	3	139
48	1	18	0	39	0	29	3	35	0	22	4	143
60	1	19	0	39	0	29	1	36	1	23	3	146
75	1	20	0	39	0	29	0	36	0	23	1	147
90	0	20	0	39	0	29	1	37	0	23	1	148
105	0	20	0	39	0	29	2	39	0	23	2	150
120	0	20	1	40	0	29	7	40	0	23	2	152

Table A-VIII (continued)

Individual Profile Scores

Hematology-Peripheral Counts

Y4

Day	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	1	1	0	0	0	0	0	0			1	1
2												
3	1	2	2	2	0	0	4	4			7	8
6	1	3	2	4	0	0	3	7	0	0	6	14
9	1	4	3	7	2	2	3	10	0	0	9	23
12	1	5	1	8	0	2	1	11	1	1	4	27
15	1	6	2	10	0	2	2	13	0	1	5	32
18	1	7	2	12	0	2	2	15	0	1	5	37
21	1	8	2	14	0	2	2	17	1	2	6	43
24	1	9	2	16	0	2	3	20	2	4	8	51
27	1	10	4	20	4	6	3	23	4	9	16	67
30	1	11	4	24	4	10	3	26	2	10	14	81
33	1	12	4	28	4	14	1	27	2	12	12	93
36	1	13	2	30	0	14	0	27	1	13	4	97
40	1	14	0	30	0	14	0	27	1	14	2	99
44	1	15	0	30	0	14	0	27	0	14	1	100
48	1	16	1	31	0	14	1	28	0	14	3	103
60	1	17	0	31	0	14	1	29	0	14	2	105
75	1	18	0	31	0	14	0	29	0	14	1	106
90	1	19	2	33	0	14	2	31	1	15	6	112
105	1	20	2	35	0	14	2	33	0	15	5	117
120	0	20	1	36	0	14	1	34	0	15	2	119

Table A-VIII (continued)

Individual Profile Scores

Hematology-Peripheral Counts

Y5

Day	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	1	1	0	0	0	0	0	0	0	0	1	1
2												
3	0	1	2	2	0	0	2	2	0	0	4	5
6	0	1	1	3	0	0	4	6	0	0	5	10
9	0	1	2	5	1	1	2	8	0	0	5	15
12	0	1	3	8	0	1	2	10	0	0	5	20
15	0	1	2	10	0	1	2	12	0	0	4	24
18	0	1	2	12	0	1	1	13	0	0	3	27
21	0	1	2	14	0	1	1	14	1	1	4	31
24	1	2	2	16	0	1	2	16	2	3	7	38
27	1	3	2	18	1	2	0	16	4	7	8	46
30	2	5	3	21	0	2	1	17	3	10	9	55
33	3	8	4	25	4	6	4	21	2	12	17	72
36	2	10	3	28	4	10	1	22	2	14	12	84
40	2	12	3	31	3	13	0	22	1	15	9	93
44	2	14	3	34	3	16	0	22	0	15	8	101
48	1	15	1	35	0	16	0	22	1	16	3	104
60	1	16	0	35	0	16	2	24	0	16	3	107
75	1	17	0	35	0	16	1	25	0	16	2	109
90	0	17	2	37	0	16	3	28	0	16	5	114
105	0	17	0	37	0	16	1	29	0	16	1	115
120	0	17	0	37	0	16	1	30	0	16	1	116

Table A-VIII (continued)

Individual Profile Scores

Hematology-Peripheral Counts

<u>Y6</u>

DAY	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	0	0	0	0	0	0	0	0	0	0	0	0
2												
3	0	0	0	0	0	0	1	1	0	0	1	1
6	0	0	0	0	0	0	2	3	0	0	2	3
9	0	0	0	0	0	0	3	6	0	0	3	6
12	0	0	2	2	0	0	3	9	0	0	5	11
15	0	0	1	3	0	0	0	9	0	0	1	12
18	0	0	0	3	0	0	1	10	0	0	1	13
21	0	0	0	3	0	0	1	11	1	1	2	15
24	0	0	0	3	0	0	2	13	2	3	4	19
27	0	0	0	3	0	0	0	13	2	5	2	21
30	0	0	1	4	0	0	0	13	2	7	3	24
33	1	1	2	6	2	2	0	13	1	8	6	30
36	1	2	2	8	2	4	0	13	1	9	6	36
40	1	3	2	10	1	5	0	13	1	10	5	41
44	1	4	1	11	0	5	0	13	0	10	2	43
48	1	5	0	11	0	5	0	13	0	10	1	44
60	0	5	0	11	0	5	0	13	0	10	0	44
75	0	5	0	11	0	5	0	13	0	10	0	44
90	0	5	0	11	0	5	4	17	0	10	4	48
105	0	5	0	11	0	5	1	18	0	10	1	49
120	0	5	0	11	0	5	2	20	0	10	2	51

Table A-VIII (continued)

Individual Profile Scores

Hematology-Peripheral Counts

LA11

DAY	ERY		WBC		NEUT		LYMPH		PLAT		TOTAL	
	I	C	I	C	I	C	I	C	I	C	I	C
1	2	2	3	3	4	4	4	4			13	13
2	0	2	3	6	4	8	4	8			11	24

Table A-IX

Cumulative Total Profile Scores through 120 Postexposure Days

Hematology-Total Blood Count

Group I

Day	Pt. LA2	LA6	LA7	LA8	LA9	LA10	A1	A2	A3	A4	OR6	OR7	OR8	Range	Mean
1	2	2	2	2	2	4	0	2	0	3	0	0	0	0- 4	1.46
2	2	4	2	4	3	6	0	2	0	4	0	0	0	0- 6	2.07
3	2	7	2	6	5	6	0	2	0	4	0	0	0	0- 7	2.61
6	2	8	3	6	5	6	1	2	0	4	4	0	0	0- 8	3.14
9	2	8	3	6	6	6	2	2	0	4	4	0	0	0- 8	3.29
12	2	8	3	6	6	6	3	2	0	4	6	0	0	0- 8	3.53
15	2	8	4	6	6	6	4	2	0	4	6	0	0	0- 8	3.68
18	2	8	5	6	6	6	5	3	0	4	6	0	0	0- 8	3.91
21	2	8	6	6	6	6	6	4	0	4	6	0	0	0- 8	4.14
24	2	8	7	6	6	6	7	5	0	4	8	0	0	0- 8	4.53
27	2	8	5	6	6	6	11	7	1	4	10	0	0	0-11	5.23
30	2	8	7	6	6	6	16	8	2	4	10	0	0	0-16	5.77
33	2	8	7	6	6	6	18	8	2	4	10	0	0	0-18	5.93
36	2	8	7	6	6	6	20	8	2	4	10	0	0	0-20	6.09
40	2	8	7	6	6	6	26	8	2	4	10	0	0	0-26	6.55
44	2	8	7	6	6	6	31	8	2	4	10	0	0	0-31	6.94
48	2	8	7	6	6	6	32	8	2	4	10	0	0	0-32	7.02
60	2	8	8	6	6	6	33	8	2	4	10	0	0	0-33	7.18
75	2	8	9	6	6	6	34	8	2	4	10	0	0	0-34	7.34
90	2	8	9	6	6	6	34	8	2	4	10	0	0	0-34	7.34
105	2	8	9	6	6	6	34	8	2	4	10	0	0	0-34	7.34
120	2	8	9	6	6	6	34	8	2	4	10	0	0	0-34	7.34

Table A-IX (continued)

Cumulative Total Profile Scores through 120 Postexposure Days

Hematology-Total Blood Count

Group II

Day	Pt.	LA4	R2	OR1	OR2	OR3	OR4	OR5	Y6	Range	Mean
1		3	2	0	2	1	2	1	0	0- 3	1.38
2		4	4	1	2	1	4	2	-	1- 4	2.38
3		6	6	3	2	1	4	2	1	1- 6	3.26
6		10	8	6	2	3	7	5	3	2- 10	5.64
9		13	10	11	3	6	7	7	6	3- 13	8.02
12		14	12	15	4	10	9	9	11	4- 15	10.65
15		14	16	19	5	12	9	10	12	5- 19	12.28
18		14	20	24	7	14	11	12	13	7- 24	14.53
21		17	24	30	14	18	17	17	15	14- 24	19.16
24		20	26	39	24	22	26	23	19	19- 39	25.04
27		23	31	53	35	26	34	29	21	21- 53	31.67
30		25	36	66	50	33	53	36	24	24- 66	39.30
33		27	48	80	64	40	52	44	30	27- 80	48.43
36		29	59	92	77	46	60	50	36	29- 92	56.43
40		31	70	100	82	51	66	54	41	31-100	62.18
44		31	78	106	84	54	70	59	43	31-106	65.93
48		31	86	108	86	57	72	60	44	31-108	68.31
60		31	87	109	88	58	74	62	44	31-109	69.44
75		31	87	110	90	59	75	62	44	31-110	70.07
90		31	87	110	92	59	75	62	48	31-110	70.82
105		31	87	110	93	59	75	62	49	31-110	71.07
120		31	87	110	93	59	75	62	51	31-110	71.32

Table A-IX (continued)

Cumulative Total Profile Scores through 120 Postexposure Days

Hematology-Total Blood Count

Group III

Day	Pt.	LA1	Y2	Y3	Y4	Y5	Range	Mean
1		4	1	1	1	1	1- 4	1.60
2		10	-	-	-	-	10	7.60
3		17	10	6	8	5	5- 17	14.00
6		25	19	13	14	10	10- 25	21.00
9		32	27	19	23	15	15- 32	28.00
12		38	38	26	27	20	20- 38	34.60
15		43	47	35	32	24	24- 47	41.00
18		45	56	48	37	27	27- 56	47.40
21		50	67	60	43	31	31- 67	55.00
24		63	79	77	51	38	38- 79	66.40
27		75	97	94	67	46	46- 97	80.60
30			113	111	81	55	55-113	94.60
33			130	121	93	72	72-130	108.60
36			146	131	97	84	84-146	119.10
40			162	136	99	93	93-162	127.10
44			176	139	100	101	100-176	133.60
48			185	143	103	104	103-185	138.35
60			195	146	105	107	105-195	142.85
75			198	147	106	109	106-198	144.60
90			204	148	112	114	112-204	149.10
105			211	150	117	115	115-211	152.85
120			219	152	119	116	116-219	156.10

Table A-IX (continued)

Cumulative Total Profile Scores through 120 Postexposure Days

Hematology-Total Blood Count

		Group IV				Group V	
Day	Pt.	LA3	Y1	Range	Mean	LA11	Mean
1		5	1	1- 5	3.00	13	13.00
2		12		12	10.00	24	24.00
3		22	6	6- 22	17.50		
6		36	14	14- 36	28.50		
9		52	25	25- 52	42.00		
12			39	39	56.00		
15			40	48	65.00		
18			60	60	77.00		
21			76	76	93.00		
24			88	88	105.00		
27			104	104	121.00		
30			110	110	127.00		

TABLE A-X. GROUP PROFILE SCORES – HEMATOLOGY-PERIPHERAL COUNTS

GROUP I

Day	Erythrocytes Integral Range	Erythrocytes Integral Mean	Erythrocytes Cumulative Range	Erythrocytes Cumulative Mean	Leucocytes Integral Range	Leucocytes Integral Mean	Leucocytes Cumulative Range	Leucocytes Cumulative Mean	Neutrophils Integral Range	Neutrophils Integral Mean	Neutrophils Cumulative Range	Neutrophils Cumulative Mean
1	0	0	0	0	0–2	0.54	0–2	0.54	0–2	0.69	0–2	0.69
2	0	0	0	0	0–1	0.23	0–3	0.77	0–1	0.23	0–3	0.92
3	0	0	0	0	0–1	0.23	0–3	1.00	0–1	0.23	0–3	1.15
6	0	0	0	0	0–2	0.15	0–3	1.15	0–2	0.15	0–3	1.30
9	0	0	0	0	0	0	0–3	1.15	0	0	0–3	1.30
12	0	0	0	0	0–1	0.08	0–3	1.23	0–1	0.08	0–3	1.38
15	0	0	0	0	0	0	0–3	1.23	0	0	0–3	1.38
18	0–1	0.08	0–1	0.08	0	0	0–3	1.23	0	0	0–3	1.38
21	0–1	0.08	0–2	0.16	0	0	0–3	1.23	0	0	0–3	1.38
24	0–1	0.08	0–3	0.24	0–1	0.08	0–4	1.31	0–1	0.08	0–4	1.46
27	0–1	0.23	0–4	0.47	0–1	0.08	0–5	1.39	0–1	0.08	0–5	1.54
30	0–1	0.23	0–5	0.70	0–1	0.08	0–5	1.47	0	0	0–5	1.54
33	0–1	0.08	0–5	0.78	0–1	0.08	0–5	1.55	0	0	0–5	1.54
36	0–1	0.08	0–5	0.86	0–1	0.08	0–5	1.63	0	0	0–5	1.54
40	0–1	0.08	0–5	0.94	0–2	0.15	0–5	1.78	0–2	0.15	0–5	1.69
44	0–1	0.08	0–6	1.02	0–2	0.15	0–7	1.93	0–1	0.08	0–5	1.77
48	0–1	0.08	0–7	1.10	0	0	0–7	1.93	0	0	0–5	1.77
60	0–1	0.08	0–8	1.18	0	0	0–7	1.93	0	0	0–5	1.77
75	0–1	0.08	0–9	1.26	0	0	0–7	1.93	0	0	0–5	1.77
90	0	0	0–9	1.26	0	0	0–7	1.93	0	0	0–5	1.77
105	0	0	0–9	1.26	0	0	0–7	1.93	0	0	0–5	1.77
120	0	0	0–9	1.26	0	0	0–7	1.93	0	0	0–5	1.77

Day	Lymphocytes Integral Range	Lymphocytes Integral Mean	Lymphocytes Cumulative Range	Lymphocytes Cumulative Mean	Platelets Integral Range	Platelets Integral Mean	Platelets Cumulative Range	Platelets Cumulative Mean	Total Integral Range	Total Integral Mean	Total Cumulative Range	Total Cumulative Mean
1	0–1	0.23	0–1	0.23	0	0	0	0	0–4	1.46	0–4	1.46
2	0–1	0.15	0–2	0.38	0	0	0	0	0–2	0.61	0–6	2.07
3	0–1	0.08	0–2	0.46	0	0	0	0	0–3	0.54	0–7	2.61
6	0–1	0.23	0–2	0.69	0	0	0	0	0–4	0.53	0–8	3.14
9	0–1	0.15	0–3	0.84	0	0	0	0	0–1	0.15	0–8	3.29
12	0–1	0.08	0–3	0.92	0	0	0	0	0–2	0.24	0–8	3.53
15	0–1	0.15	0–4	1.07	0	0	0	0	0–1	0.15	0–8	3.68
18	0–1	0.15	0–5	1.22	0	0	0	0	0–1	0.23	0–8	3.91
21	0–1	0.15	0–6	1.37	0	0	0	0	0–1	0.23	0–8	4.14
24	0–1	0.15	0–7	1.52	0	0	0	0	0–2	0.39	0–8	4.53
27	0–1	0.08	0–8	1.60	0–2	0.23	0–2	0.23	0–4	0.70	0–11	5.23
30	0	0	0–8	1.60	0–3	0.23	0–5	0.46	0–5	0.54	0–16	5.77
33	0	0	0–8	1.60	0	0	0–5	0.46	0–2	0.16	0–18	5.93
36	0	0	0–8	1.60	0	0	0–5	0.46	0–2	0.16	0–20	6.09
40	0–1	0.08	0–9	1.68	0	0	0–5	0.46	0–6	0.46	0–26	6.55
44	0–1	0.08	0–10	1.76	0	0	0–5	0.46	0–5	0.39	0–31	6.94
48	0	0	0–10	1.76	0	0	0–5	0.46	0–1	0.08	0–32	7.02
60	0–1	0.08	0–10	1.84	0	0	0–5	0.46	0–1	0.16	0–33	7.18
75	0–1	0.08	0–10	1.92	0	0	0–5	0.46	0–1	0.16	0–34	7.34
90	0	0	0–10	1.92	0	0	0–5	0.46	0	0	0–34	7.34
105	0	0	0–10	1.92	0	0	0–5	0.46	0	0	0–34	7.34
120	0	0	0–10	1.92	0	0	0–5	0.46	0	0	0–34	7.34

TABLE A-X (continued)

GROUP II

Day	Erythrocytes				Leucocytes				Neutrophils				Lymphocytes				Platelets				Total			
	Integral		Cumulative		Integral		Cumulative		Integral		Cumulative		Integral		Cumulative		Integral		Cumulative		Integral		Cumulative	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	0	0	0	0	0–1	0.25	0–1	0.25	0–1	0.25	0–1	0.25	0–2	0.88	0–2	0.88	0	0	0	0	0–2	1.38	0–3	1.38
2	0	0	0	0	0	0	0–1	0.25	0	0	0–1	0.25	0–2	1.00	0–4	1.88	0	0	0	0	0–2	1.00	1–4	2.38
3	0	0	0	0	0	0	0–1	0.25	0	0	0–1	0.25	0–2	0.88	0–6	2.76	0	0	0	0	0–2	0.88	1–6	3.26
6	0	0	0	0	0–2	0.50	0–2	0.75	0	0	0–1	0.25	0–4	1.88	0–8	4.64	0	0	0	0	0–4	2.38	2–10	5.64
9	0–1	0.13	0–1	0.13	0–2	0.75	0–3	1.50	0–1	0.13	0–1	0.38	0–3	1.38	1–10	6.02	0	0	0	0	0–5	2.38	3–13	8.02
12	0	0	0–1	0.13	0–2	1.00	0–5	2.50	0–1	0.13	0–2	0.51	0–3	1.25	2–12	7.27	0–1	0.25	0–1	0.25	1–4	2.63	4–15	10.65
15	0	0	0–1	0.13	0–2	0.75	1–6	3.25	0	0	0–2	0.51	0–3	0.75	2–15	8.02	0–1	0.13	0–2	0.38	0–4	1.63	5–19	12.28
18	0–1	0.13	0–1	0.26	0–1	0.50	2–7	3.75	0	0	0–2	0.51	0–3	0.75	2–18	8.77	0–2	0.88	0–4	1.26	0–5	2.25	7–24	14.53
21	0–1	0.50	0–3	0.76	0–2	0.88	2–8	4.63	0	0	0–2	0.51	0–3	1.38	2–21	10.15	1–3	1.88	1–6	3.14	2–7	4.63	14–24	19.16
24	0–1	0.50	0–4	1.26	0–2	1.13	3–10	5.76	0–2	0.38	0–2	0.89	0–2	1.13	2–21	11.28	1–4	2.75	2–9	5.89	2–9	5.88	19–39	25.04
27	0–2	0.25	0–6	1.51	0–3	1.63	3–13	7.39	0–4	1.13	0–6	2.02	0–2	0.63	2–23	11.91	2–4	3.00	4–12	8.89	2–13	6.63	21–53	31.67
30	0–1	0.25	0–6	1.76	1–4	2.25	4–17	9.64	0–4	1.63	0–10	3.65	0–2	0.75	2–25	13.03	1–4	2.75	6–15	11.64	2–14	7.63	24–66	39.30
33	0–3	0.88	0–9	2.64	1–3	2.38	6–20	12.02	0–4	2.13	1–13	5.78	0–2	1.00	2–27	13.66	1–4	2.75	8–18	14.39	2–13	9.13	27–80	48.43
36	0–3	0.88	0–12	3.52	1–3	2.38	8–23	14.40	0–4	2.25	1–16	8.03	0–2	0.63	2–29	14.29	1–3	1.88	9–20	16.17	2–13	8.00	29–92	56.43
40	0–3	1.00	0–15	4.52	1–3	1.88	9–25	16.28	0–3	1.50	1–19	9.53	0–2	0.25	2–31	14.54	0–3	1.13	10–21	17.30	2–11	5.75	31–100	62.18
44	0–3	1.13	0–18	5.65	0–2	1.25	9–27	17.53	0–2	0.75	1–20	10.28	0–2	0.38	2–33	14.92	0–2	0.25	10–21	17.55	0–8	3.75	31–106	65.93
48	0–2	0.75	0–20	6.40	0–2	0.63	9–27	18.16	0–2	0.50	1–20	10.78	0–2	0.25	2–35	15.17	0–2	0.25	10–21	17.80	0–8	2.38	31–108	68.31
60	0–2	0.63	0–21	7.03	0–1	0.13	9–27	18.29	0	0	1–20	10.78	0–2	0.25	2–35	15.42	0–1	0.13	10–21	17.93	0–2	1.13	31–109	69.44
75	0–2	0.63	0–22	7.66	0	0	9–27	18.29	0	0	1–20	10.78	0	0	2–35	15.42	0	0	10–21	17.93	0–2	0.63	31–110	70.07
90	0–2	0.25	0–22	7.91	0	0	9–27	18.29	0	0	1–20	10.78	0–4	0.50	2–35	15.92	0	0	10–21	17.93	0–4	0.75	31–110	70.82
105	0–1	0.13	0–22	8.04	0	0	9–27	18.29	0	0	1–20	10.78	0–1	0.13	2–35	16.05	0	0	10–21	17.93	0–1	0.51	31–110	71.07
120	0	0	0–22	8.04	0	0	9–27	18.29	0	0	1–20	10.78	0–2	0.25	2–35	16.30	0	0	10–21	17.93	0–2	0.25	31–110	71.32

TABLE A-X (continued)

GROUP III

Day	Erythrocytes				Leucocytes				Neutrophils				Lymphocytes				Platelets				Total			
	Integral		Cumulative		Integral		Cumulative		Integral		Cumulative		Integral		Cumulative		Integral		Cumulative		Integral		Cumulative	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	0–1	0.80	0–1	0.80	0–1	0.20	0–1	0.20	0–2	0.40	0–2	0.40	0–1	0.20	0–1	0.20	0	0	0	0	1–4	1.60	1–4	1.60
2	0	0	0–1	0.80	1	1.00	0–2	1.20	2	2.00	0–4	2.40	3	3.00	0–4	3.20	0	0	0	0	6	6.00	1–10	7.60
3	0–1	0.40	0–2	1.20	1–3	2.00	2–3	3.20	0–2	0.60	0–6	3.00	2–4	3.40	2–8	6.60	0	0	0	0	4–9	6.40	5–17	14.00
6	0–1	0.40	0–3	1.60	1–3	2.00	3–6	5.20	0–3	0.80	0–9	3.80	3–4	3.40	6–11	10.00	0–2	0.40	0–2	0.40	5–9	7.00	10–25	21.00
9	0–1	0.40	0–4	2.00	0–3	2.00	5–9	7.20	1–2	1.20	1–10	5.00	2–4	2.80	8–15	12.80	0–2	0.60	0–3	1.00	5–9	7.00	15–32	28.00
12	0–1	0.60	0–5	2.60	0–4	2.20	5–13	9.40	0–4	1.20	1–10	6.20	1–4	2.00	9–19	14.80	0–2	0.60	0–4	1.60	4–11	6.60	20–38	34.60
15	0–1	0.60	0–6	3.20	0–3	2.00	5–16	11.40	0–2	0.80	1–11	7.00	1–3	2.00	10–21	16.80	0–2	1.00	0–6	2.60	4–9	6.40	24–43	41.00
18	0–1	0.60	0–7	3.80	0–3	2.00	5–19	13.40	0–3	1.20	1–12	8.20	1–4	1.80	13–22	18.60	0–2	0.80	0–7	3.40	2–13	6.40	27–56	47.40
21	0–1	0.60	0–8	4.40	1–3	2.20	6–22	15.60	0–3	1.00	1–13	9.20	1–4	2.00	14–23	20.60	2–3	1.80	2–10	5.20	5–11	7.60	31–67	55.00
24	0–2	1.00	0–10	5.40	2–4	3.00	10–25	18.60	0–4	2.00	1–17	11.20	2–4	3.00	16–26	23.60	2–4	2.40	4–13	7.60	7–16	11.40	38–79	66.40
27	0–2	1.20	0–12	6.60	2–4	3.40	13–29	22.00	1–4	3.20	2–20	14.40	0–4	3.00	16–30	26.60	2–4	3.40	7–16	11.00	12–17	14.20	46–97	80.60
30	1–2	1.75	4–14	8.35	3–4	3.75	21–33	25.75	0–4	3.00	2–21	17.40	1–4	3.00	17–32	29.60	2–3	2.50	10–19	13.50	9–17	14.00	55–113	94.60
33	1–3	2.00	7–16	10.35	3–4	3.75	25–37	29.50	3–4	3.75	6–25	21.15	0–4	2.25	21–36	31.85	2–3	2.25	12–21	15.75	10–17	14.00	72–130	108.60
36	1–2	1.75	8–18	12.10	2–4	3.00	28–41	32.50	0–4	2.50	10–29	23.65	0–4	2.00	22–40	33.85	0–2	1.25	13–21	17.00	4–16	10.50	84–146	119.10
40	1–2	1.50	10–20	13.60	0–4	2.25	30–45	34.75	0–4	2.00	13–33	25.65	0–4	1.25	22–44	35.10	0–2	1.00	14–21	18.00	2–16	8.00	93–162	127.10
44	1–2	1.75	12–22	15.35	0–4	2.00	30–49	36.75	0–3	1.50	14–36	27.15	0–3	0.75	22–47	35.85	0–2	0.50	14–22	18.50	1–14	6.50	100–176	133.60
48	1–2	1.25	15–24	16.60	0–3	1.25	31–52	38.00	0–2	0.50	14–38	27.65	0–3	1.25	22–48	37.10	0–1	0.50	14–23	19.00	3–9	4.75	103–185	138.35
60	1–2	1.25	16–26	17.85	0–3	0.75	31–55	38.75	0–2	0.50	14–40	28.15	1–3	1.75	24–51	38.85	0–1	0.25	14–23	19.25	2–10	4.50	105–195	142.85
75	1	1.00	17–27	18.85	0–1	0.25	31–56	39.00	0	0	14–40	28.15	0–1	0.50	25–52	39.35	0	0	14–23	19.25	1–3	1.75	106–198	144.60
90	0–1	0.50	17–28	19.35	0–2	1.50	33–58	40.50	0	0	14–40	28.15	1–3	2.00	28–54	41.35	0–1	0.50	15–24	19.75	1–6	4.50	112–204	149.10
105	0–1	0.50	17–29	19.85	0–2	1.00	35–60	41.50	0	0	14–40	28.15	1–4	2.25	29–58	43.60	0	0	15–24	19.75	1–7	3.75	115–211	152.85
120	0–1	0.25	17–30	20.10	0–2	1.00	36–62	42.50	0–1	0.25	14–41	28.40	1–3	1.50	30–61	45.10	0–1	0.25	15–25	20.00	1–8	3.25	116–219	156.10

TABLE A-X (continued)

GROUP IV

Day	Erythrocytes				Leucocytes				Neutrophils				Lymphocytes				Platelets				Total			
	Integral		Cumulative		Integral		Cumulative		Intergral		Cumulative		Integral		Cumulative		Integral		Cumulative		Integral		Cumulative	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	0–1	0.50	0–1	0.50	0–1	0.50	0–1	0.50	0–2	1.00	0–2	1.00	0–2	1.00	0–2	1.00	0	0	0	0	1–5	3.00	1–5	3.00
2	0	0	0–1	0.50	1	1.00	0–2	1.50	2	2.00	0–4	3.00	4	4.00	0–6	5.00	0	0	0	0	7	7.00	1–12	10.00
3	0	0	0–1	0.50	1–2	1.50	1–4	3.00	0–4	2.00	0–8	5.00	4	4.00	4–10	9.00	0	0	0	0	5–10	7.50	6–22	17.50
6	0	0	0–1	0.50	2–4	3.00	3–8	6.00	0–4	2.00	0–12	7.00	4	4.00	8–14	13.00	2	2.00	2	2.00	8–14	11.00	14–36	28.50
9	0	0	0–1	0.50	3–4	3.50	6–12	9.50	3–4	3.50	3–16	10.50	3–4	3.50	11–18	16.50	2–4	3.00	4–6	5.00	11–16	13.50	25–52	42.00
12	0	0	1.0	0.50	4	4.00	10	13.50	3	3.00	6	13.50	4	4.00	15	20.50	3	3.00	7	8.00	14	14.00	39	56.00
15	0	0	1.0	0.50	2	2.00	12	15.50	0	0	6	13.50	4	4.00	19	24.50	3	3.00	10	11.00	9	9.00	48	65.00
18	1	1.00	2.0	1.50	3	3.00	15	18.50	1	1.00	7	14.50	3	3.00	22	27.50	4	4.00	14	15.00	12	12.00	60	77.00
21	1	1.00	3.0	2.50	4	4.00	19	22.50	4	4.00	11	18.50	3	3.00	25	30.50	4	4.00	18	19.00	16	16.00	76	93.00
24	1	1.00	4.0	3.50	3	3.00	22	25.50	3	3.00	14	21.50	1	1.00	26	31.50	4	4.00	22	23.00	12	12.00	88	105.00
27	1	1.00	5.0	4.50	4	4.00	26	29.50	4	4.00	18	25.50	4	4.00	30	35.50	3	3.00	25	26.00	16	16.00	104	121.00
30	1	1.00	6.0	5.50	1	1.00	27	30.50	0	0	18	25.50	4	4.00	34	39.50	0	0	25	26.00	6	6.00	110	127.00

GROUP V

Day	Erythrocytes				Leucocytes				Neutrophils				Lymphocytes				Platelets				Total			
	Integral		Cumulative		Integral		Cumulative		Integral		Cumulative		Integral		Cumulative		Integral		Cumulative		Integral		Cumulative	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
1		2.00		2.00		3.00		3.00		4.00		4.00		4.00		4.00						13.00		13.00
2		0		2.00		3.00		6.00		4.00		8.00		4.00		8.00						11.00		24.00

Table A-XI

Individual Integral Profile Scores*

Hematology-Coagulation

Patient	Day	Clot Time	PPT	SPT
		Group I		
LA2				
LA6	1	0	0	
	5	2	0	
	6	3	0	
	7	1	0	
	8	1	0	
	18	0	0	
	F	0	0	
LA7	AT	0	0	
LA8	AT	0	0	
LA9	AT	0	0	
LA10	AT	0	0	
LA12	x	x	x	x
A1	x	0	0	
A2	x	0	0	
A3	x	0		
A4	x	0		
OR6				
OR7				
OR8				

*Individual non-cumulative scores only because of inconsistency in performance of tests.

PPT - Plasma Prothrombin Time; SPT - Serum Prothrombin Time.

AT - All times tested, including follow-up period; F - All times tested during follow-up period.

x - No information available concerning test.

Blank - Test not performed.

__ - Test performed; result unknown.

Table A-XI (continued)

Individual Integral Profile Scores*

Hematology-Coagulation

Patient	Day	Clot Time	PPT	SPT
		Group II		
LA4	5	4	0	
	6	4	0	
	7	4	0	
	8	3	0	
	9	2	0	
	10	2	0	
	11	1	0	
	12	0	0	
	14	0	0	
	16	0	0	
	F	0	0	
R2	x	x	x	x
OR1	11	0	0	
	29	0	0	
	67	0	0	
OR2	11	0	0	
	29	0	0	
	67	0	0	
OR3	11	0	0	
	29	0	0	
	67	0	0	
OR4	11	0	0	
	29	0	0	
	67	0	0	
OR5	11	0	0	
	29	0	0	
	67	0	0	
Y6	—	–	–	x

Table A-XI (continued)

Individual Integral Profile Scores*

Hematology-Coagulation

Patient	Day	Clot Time	PPT	SPT
		Group III		
LA1				
R1	x	x	x	x
Y2	–	–	–	x
Y3	–	–	–	x
Y4	–	–	–	x
Y5	–	–	–	x
		Group IV		
LA3	5	4	0	
	6	4	0	
	7	4	0	
	8	4	0	
	9	4	0	
Y1	–	–	–	x
		Group V		
LA11	x	x	x	x

Table A-XII

Individual Integral Profile Scores*

Biochemistry-Blood

Patient	Day	Na	Cl	BUN	NPN	Uric Acid	Ca	Protein		
								A	G	Total
					Group I					
LA2	x	x	x	x	x	x	x	x	x	x
LA6	1	0								
	2	0								
	3		0	0		0				
	8		0	0		0		0	0	0
	14							0	0	0
	19							0	0	0
	23							0	0	0
	27							0	0	0
LA7	1	0								
	2		0	0		0				
LA8	1	0								
	3		0	0		0				
LA9	1	0								
	3		0	0		0				
LA10	1	0								
	3		0	0		0				
A1	x	x	x	x	x	x	x	x	x	x
A2	x	x	x	x	x	x	x	x	x	x
A3	x	x	x	x	x	x	x	x	x	x
A4	x	x	x	x	x	x	x	x	x	x
OR6	AT	0	0		0	0	0	0	0	0
OR7	AT	0	0		0	0	0	0	0	0
OR8	AT	0	0		0	0	0	0	0	0

*Individual non-cumulative scores only because of inconsistency in performance of tests.

x - No information available concerning test.

Blank - Test not performed.

Table A-XII (continued)

Individual Integral Profile Scores*

Biochemistry-Blood

Patient	Day	Na	Cl	BUN	NPN	Uric Acid	Ca	Protein		
								A	G	Total
					Group II					
LA4	1	0								
	2	0								
	3	0	0							
	7			0		0		0	0	0
	8		0	0		0		0	3	3
	17							0	0	0
	21							0	0	0
	28							0	0	0
R2	19		2		0					
OR1	AT	0	0		0	0	0	0	0	0
OR2	AT	0	0		0	0	0	0	0	0
OR3	AT	0	0		0	0	0	0	0	0
OR4	AT	0	0		0	0	0	0	0	0
OR5	AT	0	0		0	0	0	0	0	0
Y6[a]	AT	x	0	0		0		0	0	0
					Group III					
LA1	14				0	0				
R1	23		0					0	0	0
	28		0					0	0	0
Y2[a]	AT	x	0	0		0		0	0	0
Y3[a]	AT	x	0	0		0		0	0	0
Y4[a]	AT	x	0	0		0		0	0	0
Y5[a]	AT	x	0	0		0		0	0	0

AT - All times tested, including follow-up period.

a - K and P were also normal for all times tested.

Table A-XII (continued)

Individual Integral Profile Scores*

Biochemistry-Blood

Patient	Day	Na	Cl	BUN	NPN	Uric Acid		Protein		
								A	G	Total
					Group IV					
LA3	1	0								
	2	0	0	0		0				
	3	0								
	4	0	2		1			0	0	1
	8		2	1		0	1	0	0	0
	9		3		4		0	0	0	0
Y1[(b)]	x	–	–	x	x	x	x	x	x	x
					Group V					
LA11	1				1	4				

b - Na and Cl levels were decreased and K level was increased during the first postirradiation week and terminally, but degrees of abnormalities were not reported.

\- Test performed; result unknown.

Table A-XIII

Individual Integral Profile Scores*

Biochemistry-Urine

Patient	Day	Coproporphyrin μg %	Coproporphyrin μg/day	Urobilinogen mg/day
		Group I		
LA2				
LA6	AT	0	0	0
LA7	1	0	0	0
LA8	1	1	0	0
LA9	1	0	0	0
LA10	1	0	0	0
		Group II		
LA4	1	2	0	0
	2	2	4	0
	5	1	1	0
	6	1	0	3
	7	0	0	0
	8	0	0	0
	9	0	1	0
	11	0	0	0
	18	0	0	0
	21	0	2	0
	24	0	0	0
	26	0	1	0

*Individual non-cumulative scores only because of inconsistency in performance of tests.

No information is available concerning the performance of these tests in any but the Los Alamos patients except for the notation that there was an irregular increase in bile pigment excretion in some of the Yugoslav patients.

AT - All times tested, including follow-up period.

Blank - Test not performea or reported.

Table A-XIII

Individual Integral Profile Scores*

Biochemistry-Urine

Patient	Day	Coproporphyrin		Urobilinogen
		µg %	µg/day	mg/day
		Group III		
LA1	24	3	3	
		Group IV		
LA3	1	0		
	2	0		0
	5	2	2	0
	6	3	4	0
	7	3	0	3
		Group V		
LA11	x	x	x	x

x - No information available concerning tests.

Table A-XIV

Amino Acids and Acid Hydrolysates of Normal Urine

Amino Acids	Units	Average	Range	Range of Hydrolysates
Taurine	mg/day	156		
Aspartic		10	0 - 1	70 - 175
Threonine		28	19 - 25	40 - 103
Serine		43	21 - 27	70 - 206
Asparagine		54		
Glutamic		10	0 - 61	343 - 420
Proline		10	7 - 15	43 - 86
Glycine		132	120 - 737	300 - 714
Alanine		46		81 - 142
Aminoadipic		10		
Cystine		10	40 - 108	88 - 200
Valine		10	4 - 12	8 - 60
Methionine		10	2 - 8	
Isoleucine		18	4 - 14	18 - 59
Leucine		14	0 - 13	20 - 94
Tyrosine		35	11 - 23	55 - 70
Phenylalanine		18	3 - 16	24 - 66
Histidine		216	69 - 188	130 - 378
Methylhistidine		180		
Lysine		19	1 - 47	42 - 100
Arginine		10	4 - 21	Trace 57
	Total -	979		

Beta Aminoisobutyric Acid - 150 μM/day (maximum)

Procedures not sufficiently standardized to warrant assignment of profile values of any significance or reliability.

Table A-XV

Urinary Amino Acid Excretion

Increased Excretion (postirradiation day)	Patients											
	LA1	LA3	LA4	LA8	LA9	A1	A2	A3	A4	OR1	OR2	OR5
Onset	23	1	1	1	1	1	3	1	1	1	1	
Peak	23	6	6	1	1	6	6	8	6	4	4	4
Duration		9	12			150	120	155	120	16		

Amino Acids Excreted (by accident groups)	LASL-I-II	Argonne	Oak Ridge	Yugoslavia
Alanine	x	x		x
Arginine	x			x
Aspartic	x	x		x
Cysteic Acid	x	x		
Cystine		x		x
Glutamic Acid	x	x		x
Glutamine		x		x
Glycocolle				x
Glycine	x	x		
Histidine		x		x
Hydroxyproline	x	x		
Leucine	x	x		x
Lycine				x
Methionine				x
Methylhistidine				x
Phenylalanine	x			x
Proline				x
Serine	x	x		x
Taurine	x	x	x	
Threonine				x
Tryptophane				x
Tyrosine				x
Valine	x	x		x

Table A-XVI

Urine Beta Aminoisobutyric Acid (BAIBA) Excretion in Oak Ridge Patients

Patient --	OR1	OR2	OR3	OR4	OR5	OR6	OR7	OR8
Dose (rad)								
N_f	96	89	86	71	62	18	18	6
γ	269	250	241	199	174	50.5	50.5	16.8
Total	365	339	327	270	236	68.5	68.5	22.8
Day								
3	++	+	++	0	±	+	0	0
4	+++	++	++	+	+	0	0	0
5	++	+	+	±	±			
6	++	+	+	±	0			
7	+	+	+	±	±			
8	+	+	±	±	±			

0 - 50 μ M/L BAIBA

± - 75 μ M/L BAIBA

\+ - 125 μ M/L BAIBA

++ - 250 μ M/L BAIBA

+++ - 500 μ M/L BAIBA

Extracted from Rubini, J. R. in Reference 7.

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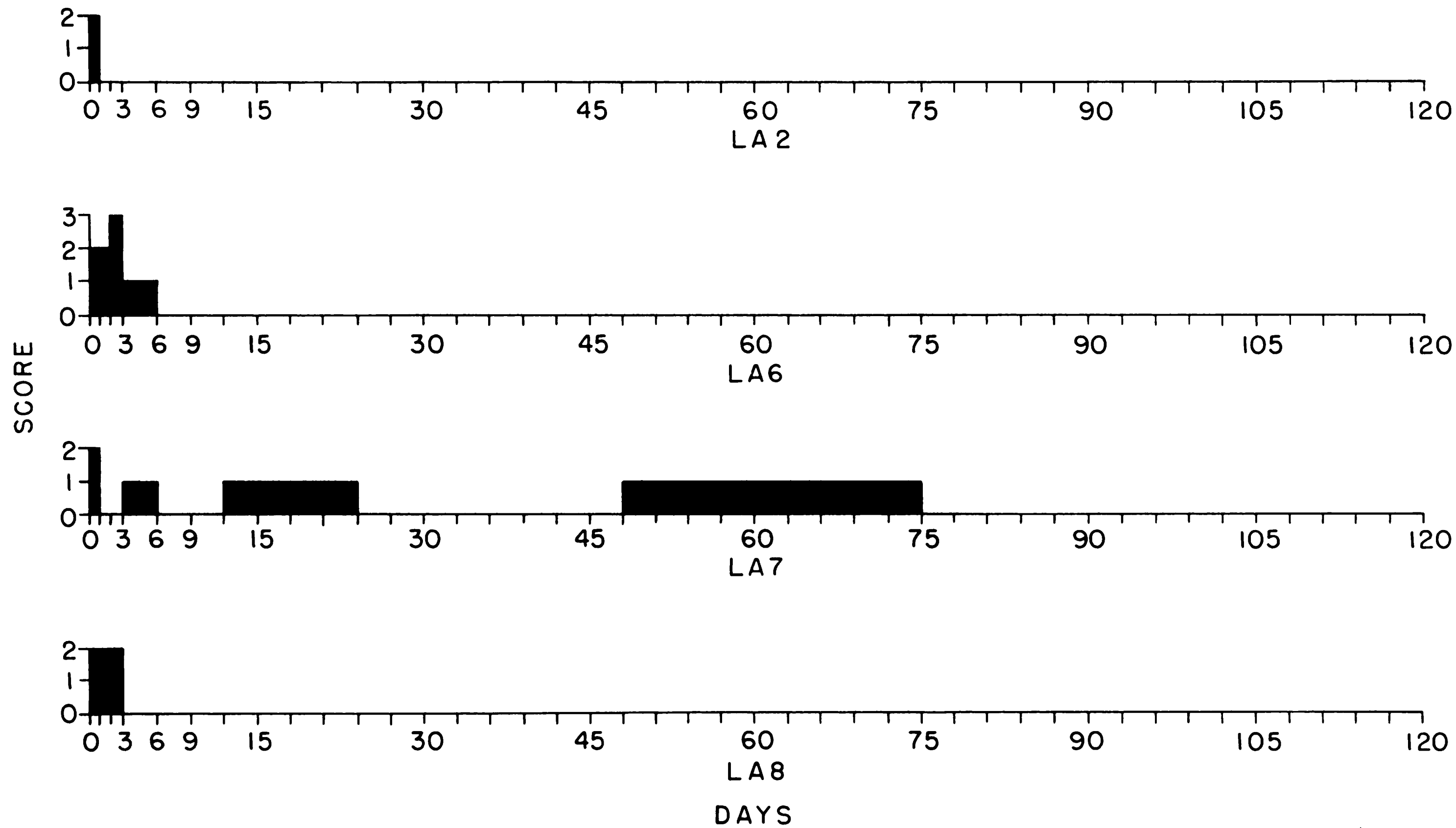

FIG. A-I
INDIVIDUAL TEST PROFILE SCORES-HEMATOLOGY-TOTAL BLOOD COUNT
GROUP-I

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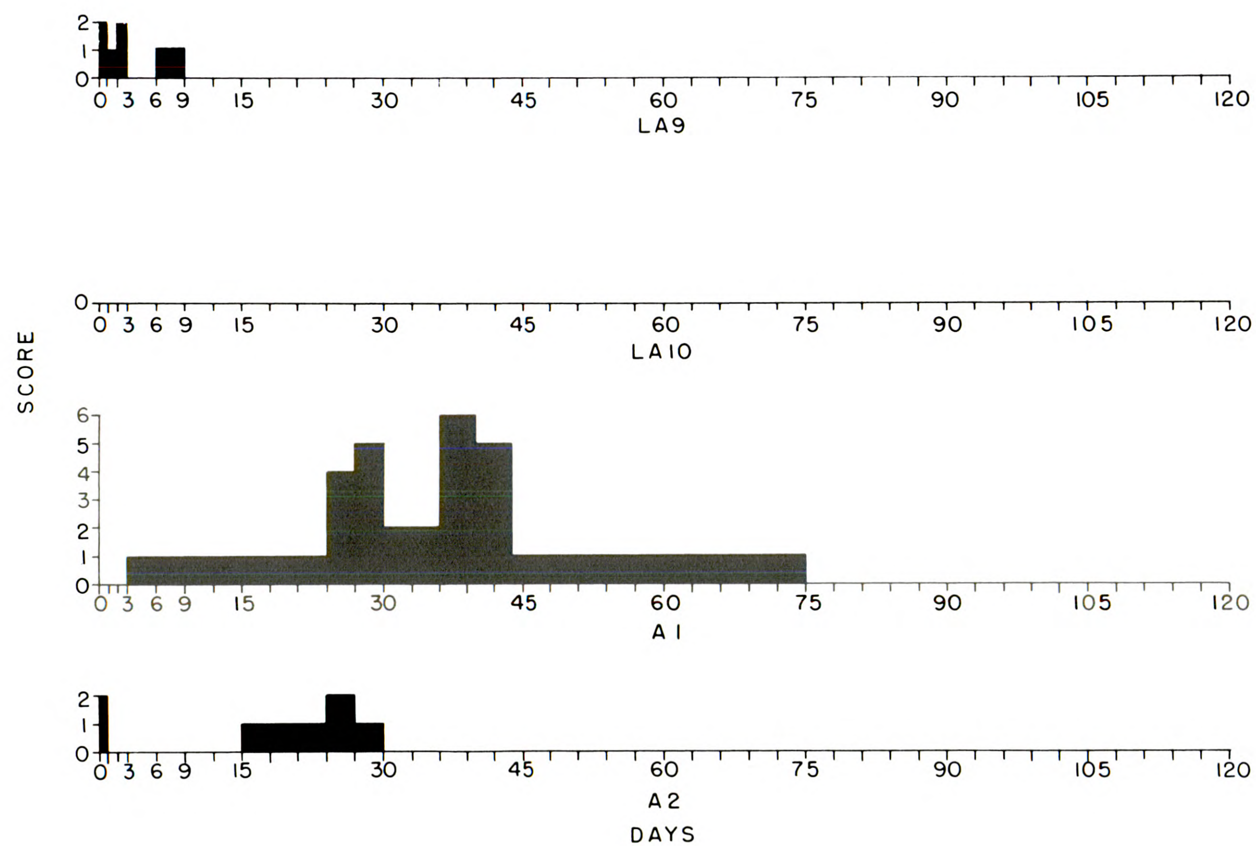

FIG. A-2
INDIVIDUAL TEST PROFILE SCORES - HEMATOLOGY - TOTAL BLOOD COUNT
GROUP I

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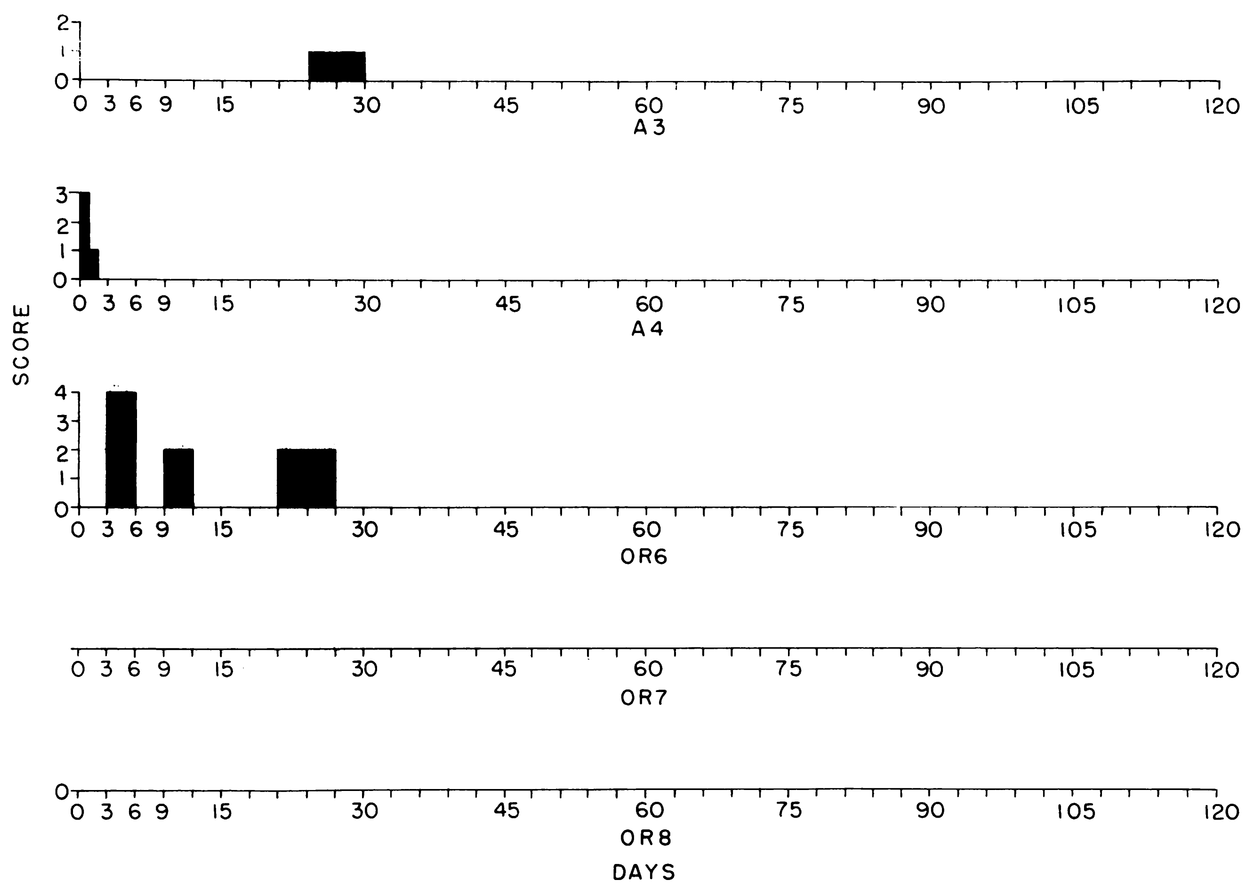

FIG. A-3
INDIVIDUAL TEST PROFILE SCORES-HEMATOLOGY-TOTAL BLOOD COUNT
GROUP I

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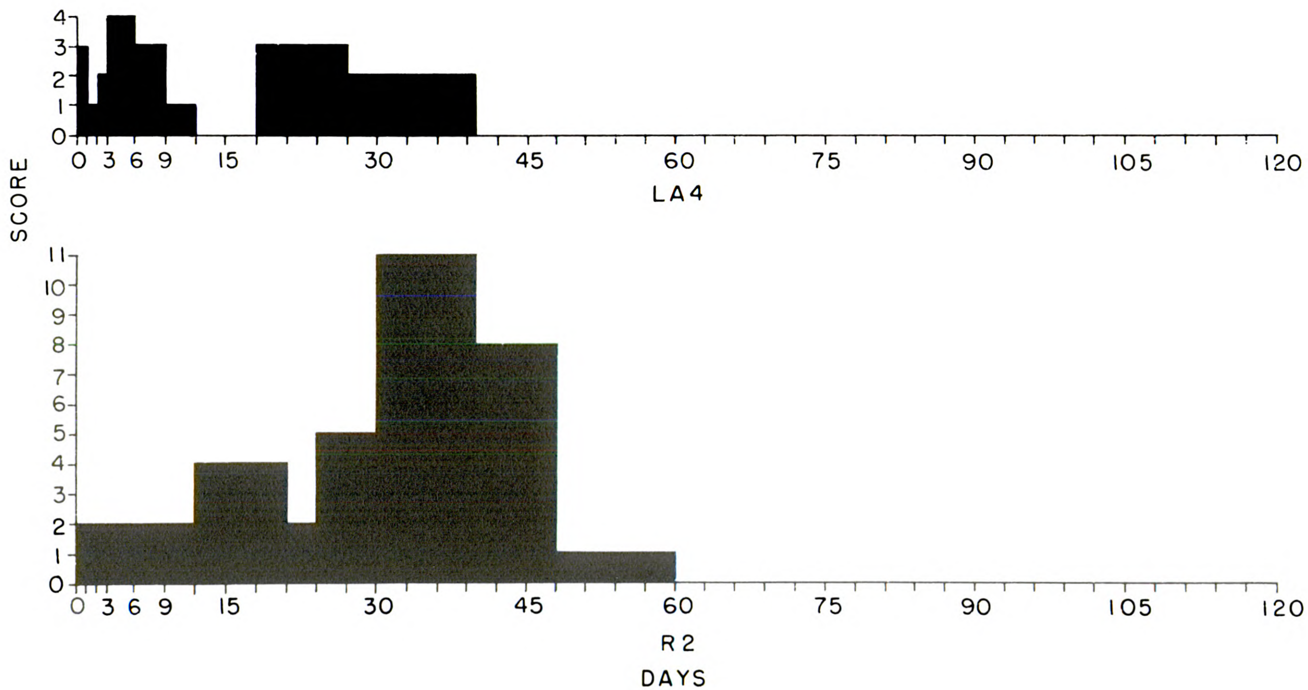

FIG. A-4
INDIVIDUAL TEST PROFILE SCORES-HEMATOLOGY-TOTAL BLOOD COUNT
GROUP II

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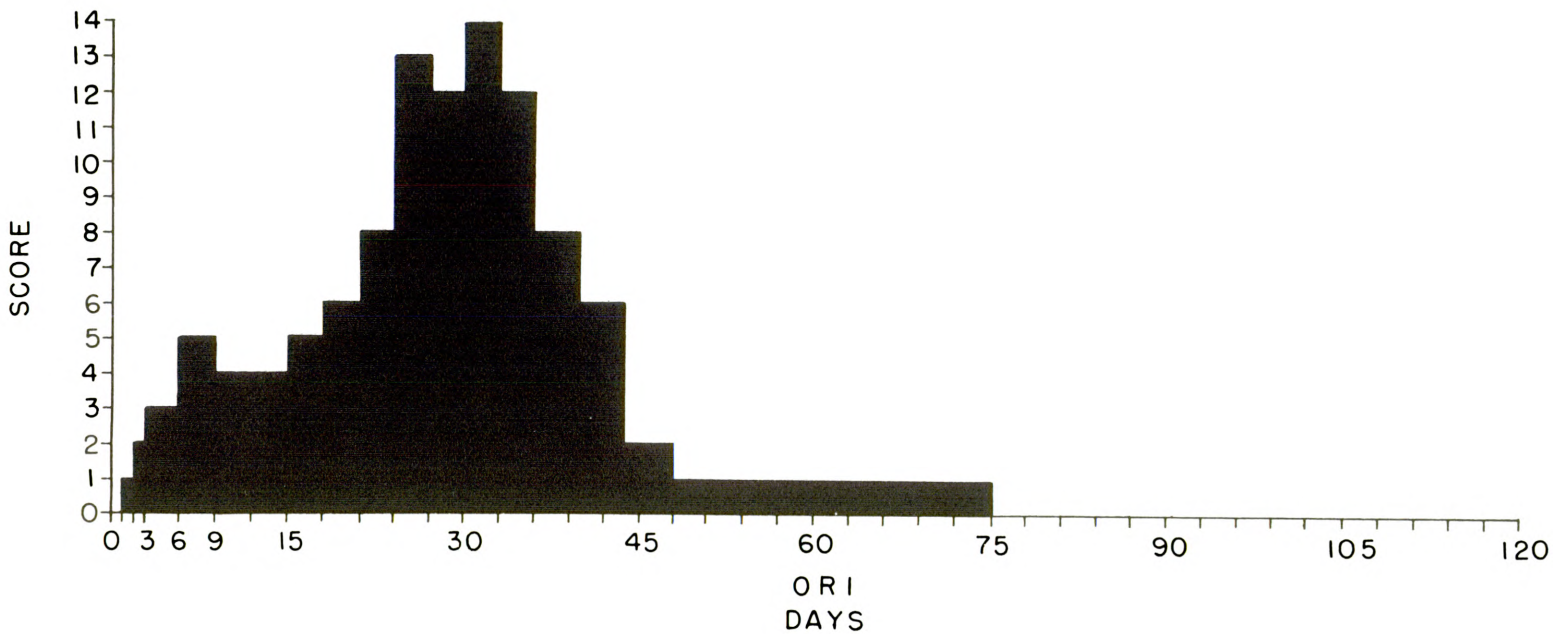

FIG. A-5
INDIVIDUAL TEST PROFILE SCORES - HEMATOLOGY - TOTAL BLOOD COUNT
GROUP II

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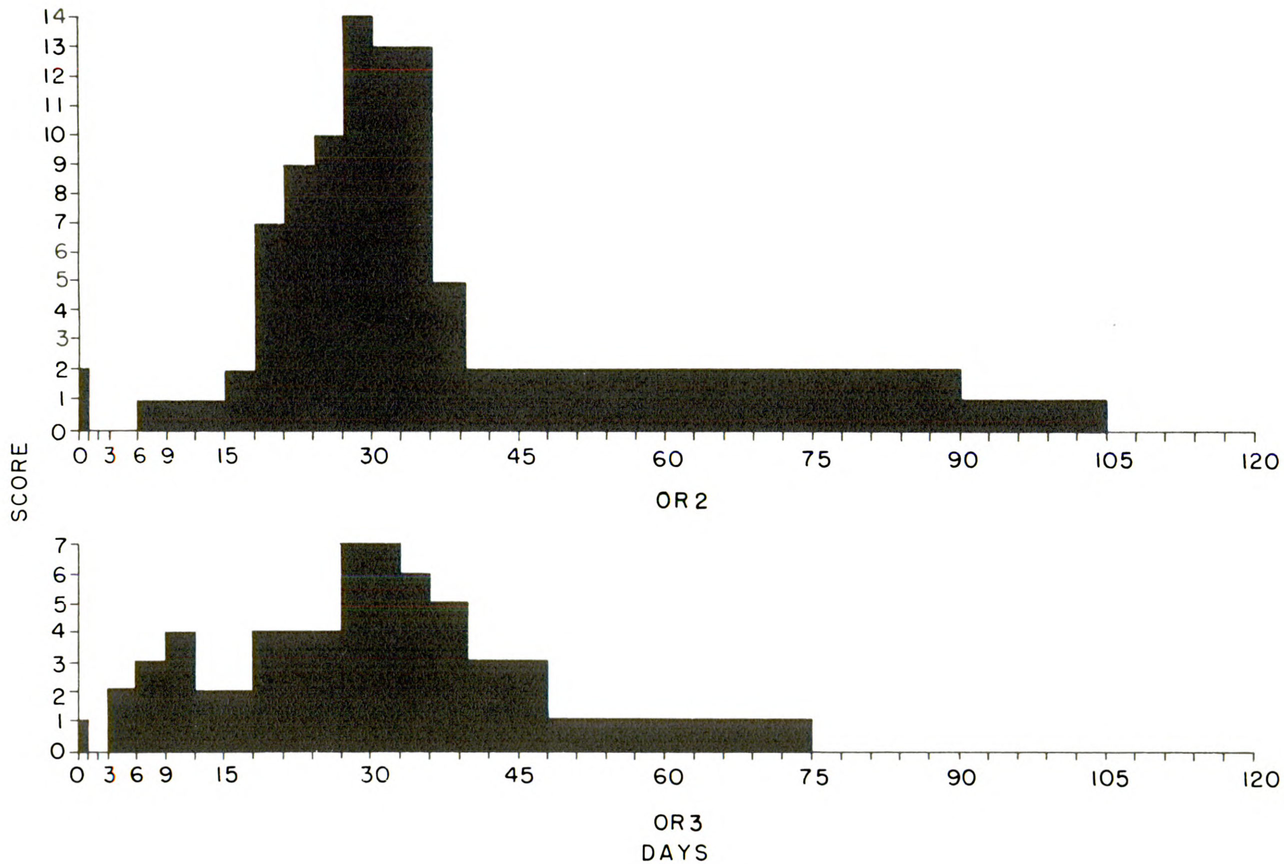

FIG. A-6
INDIVIDUAL TEST PROFILE SCORES-HEMATOLOGY-TOTAL BLOOD COUNT
GROUP II

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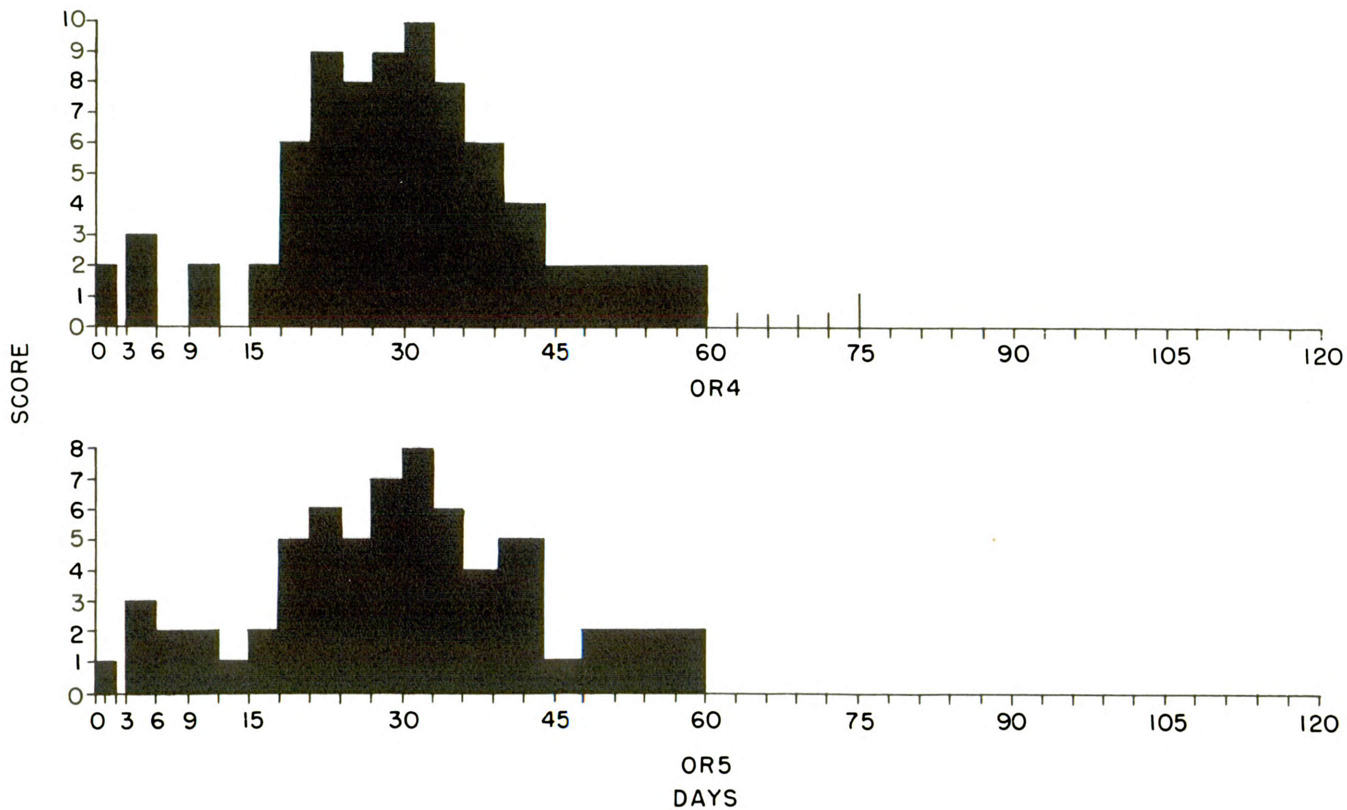

FIG. A-7
INDIVIDUAL TEST PROFILE SCORES-HEMATOLOGY-TOTAL BLOOD COUNT
GROUP II

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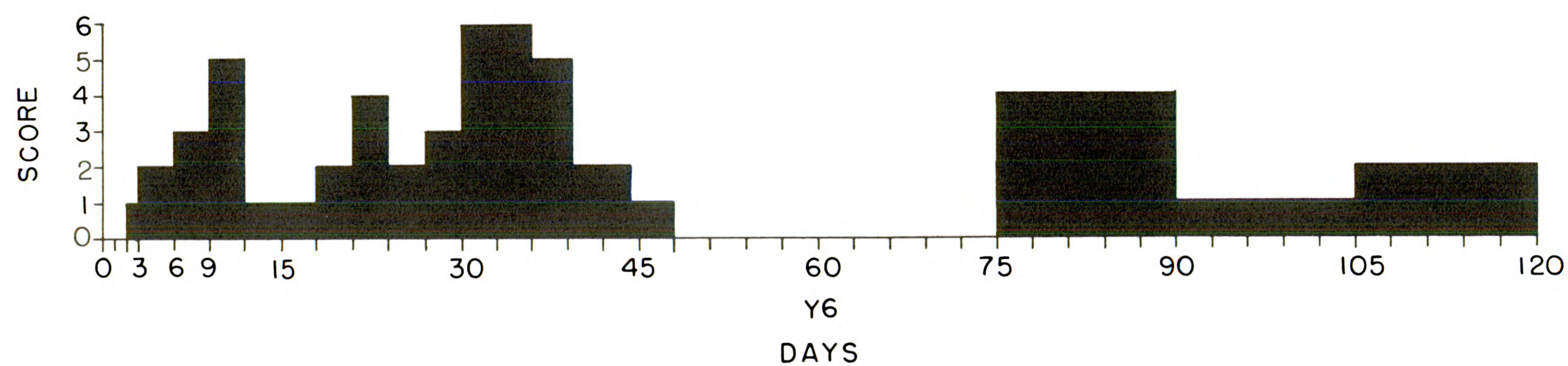

FIG. A-8
INDIVIDUAL TEST PROFILE SCORES - HEMATOLOGY - TOTAL BLOOD COUNT
GROUP II

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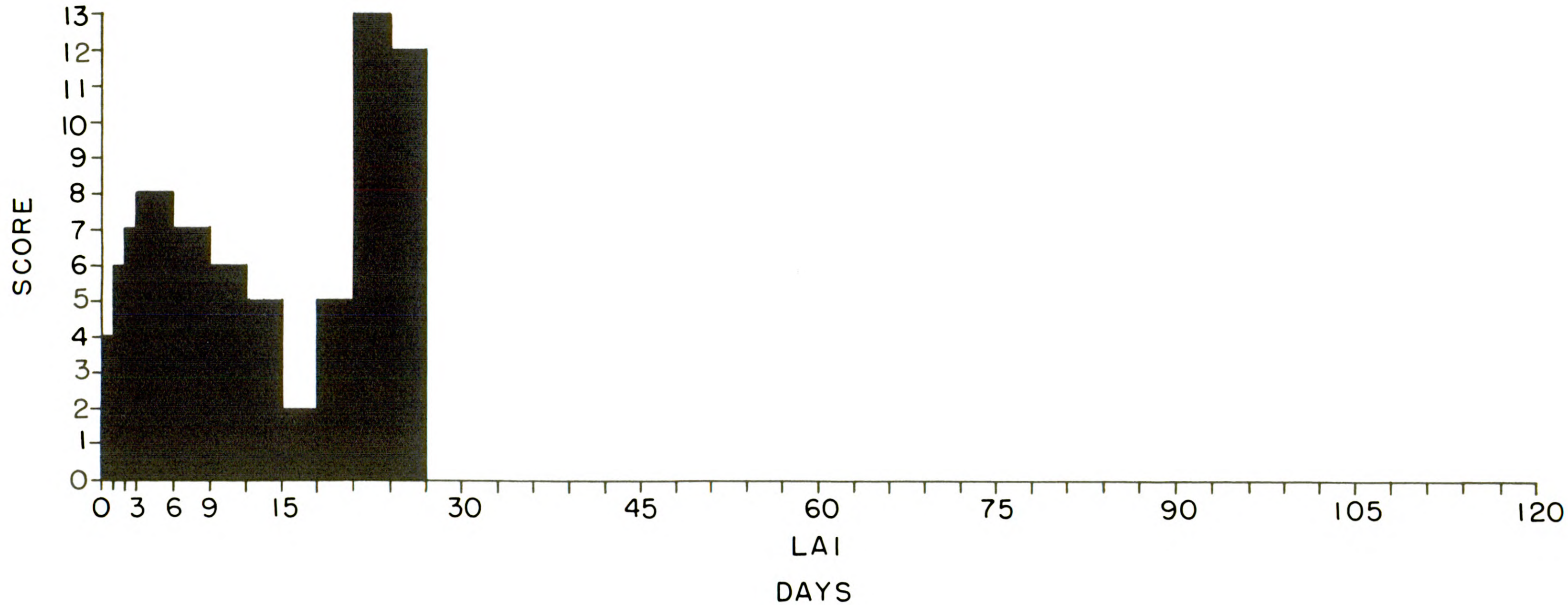

FIG. A-9
INDIVIDUAL TEST PROFILE SCORES - HEMATOLOGY - TOTAL BLOOD COUNT
GROUP III

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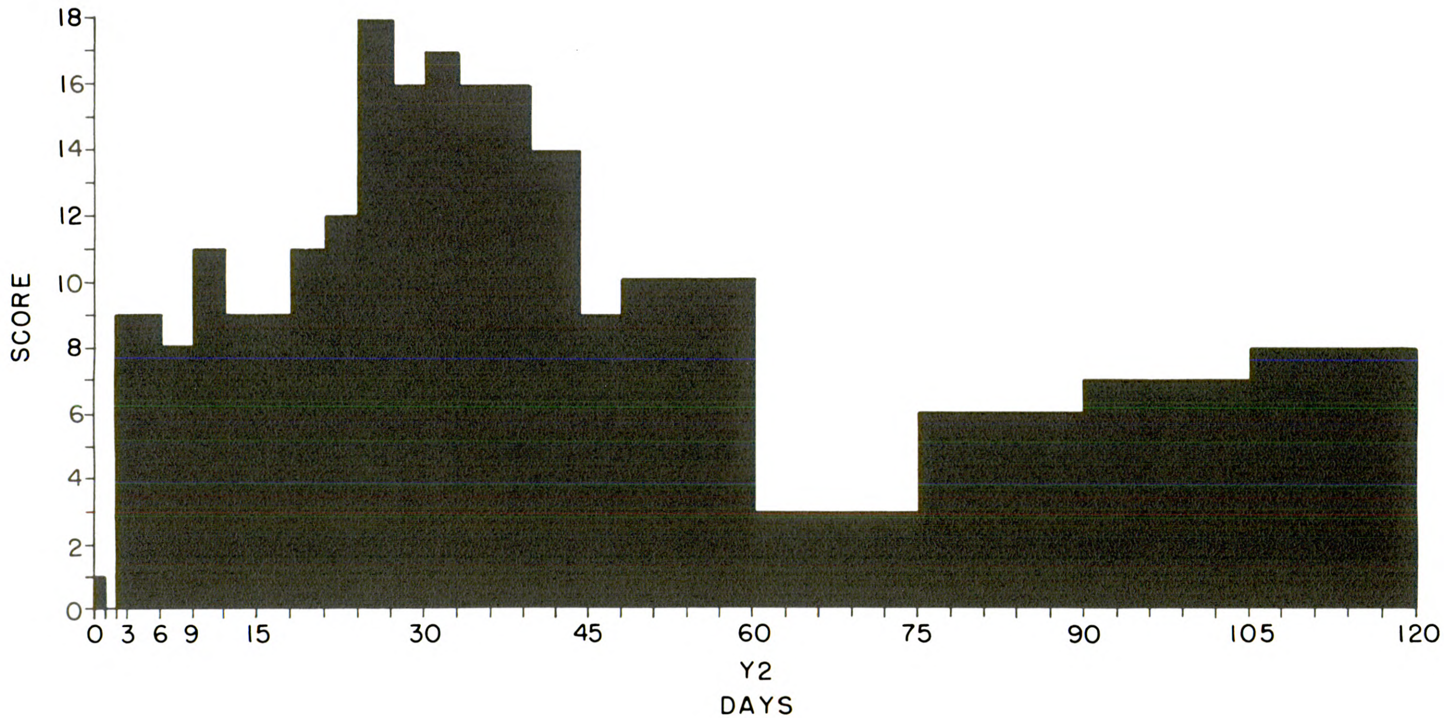

FIG. A-10
INDIVIDUAL TEST PROFILE SCORES–HEMATOLOGY–TOTAL BLOOD COUNT
GROUP III

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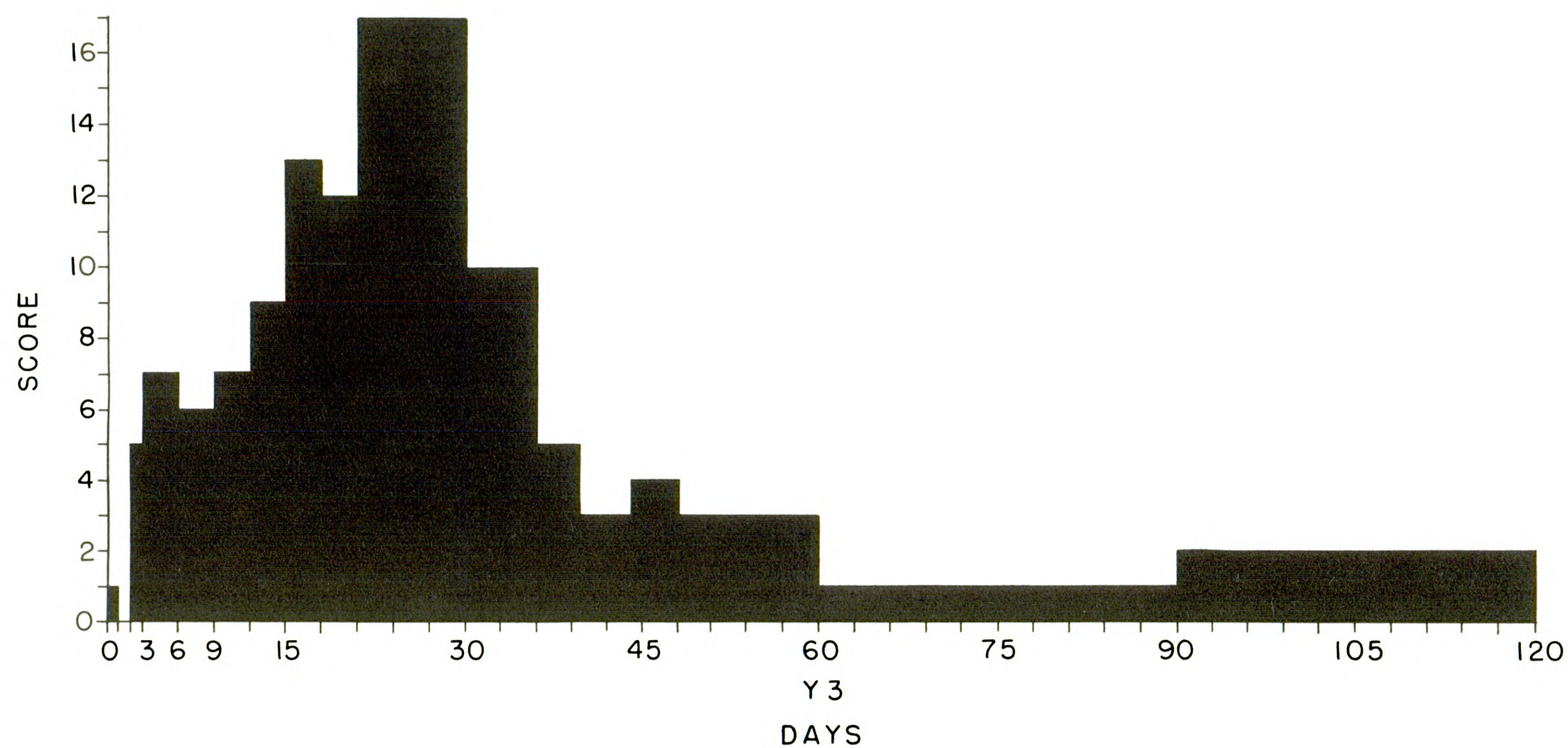

FIG. A-11
INDIVIDUAL TEST PROFILE SCORES-HEMATOLOGY-TOTAL BLOOD COUNT
GROUP-III

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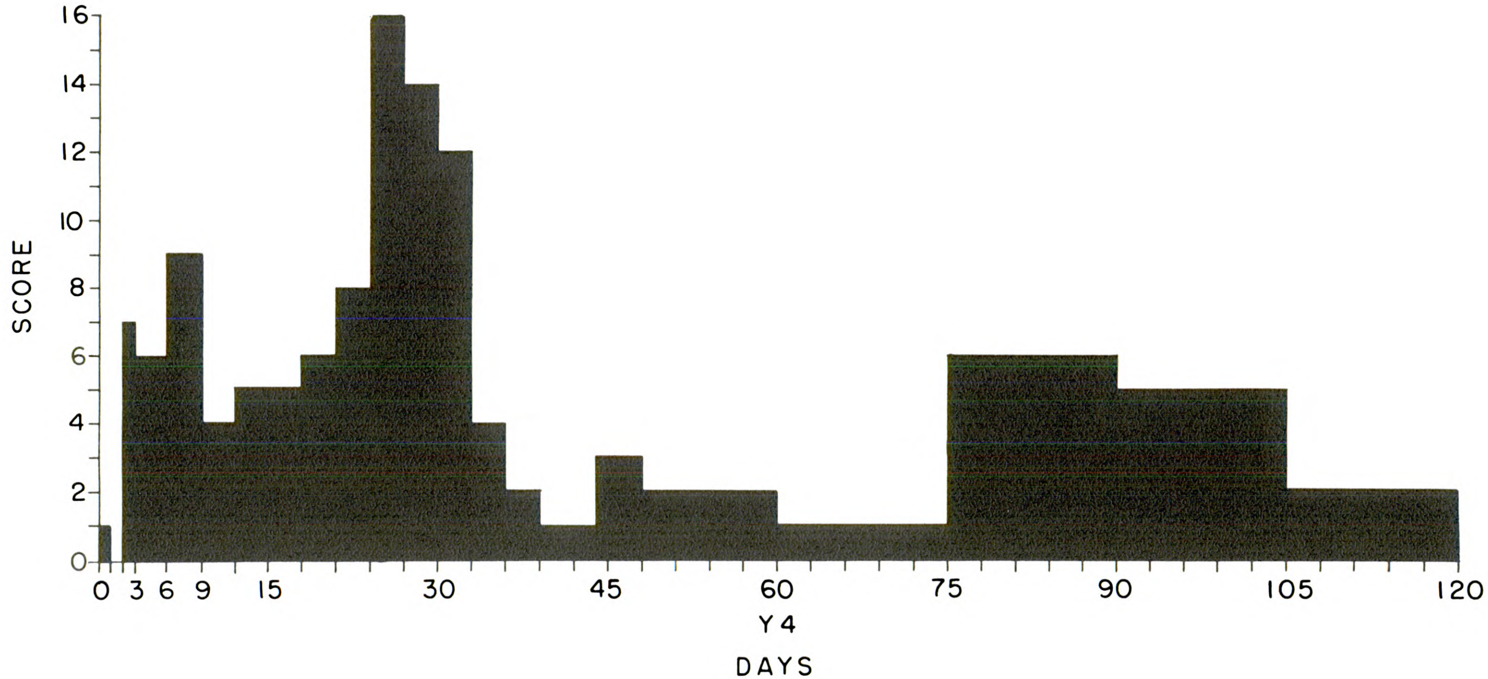

FIG. A-12
INDIVIDUAL TEST PROFILE SCORES-HEMATOLOGY-TOTAL BLOOD COUNT
GROUP III

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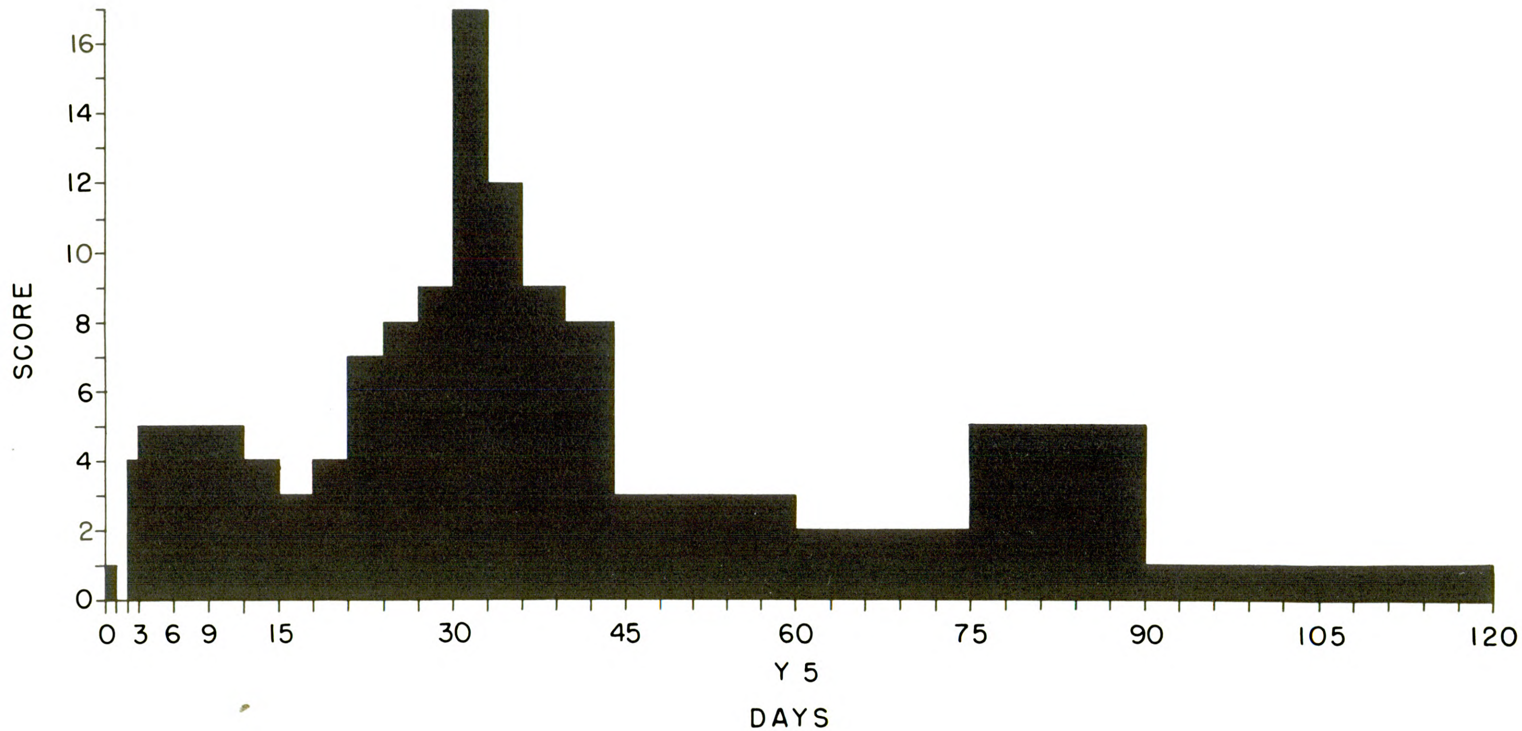

FIG. A-13
INDIVIDUAL TEST PROFILE SCORES-HEMATOLOGY-TOTAL BLOOD COUNT
GROUP III

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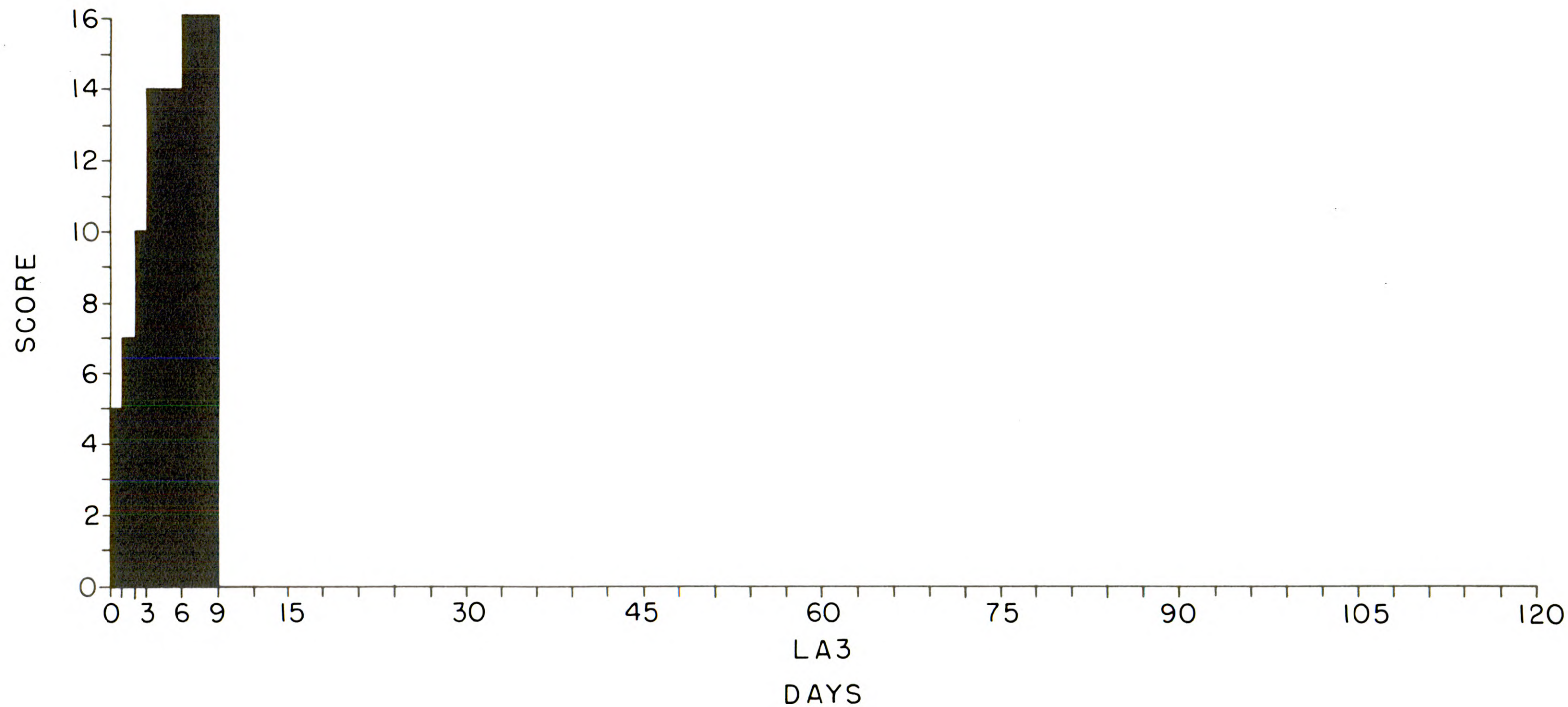

FIG. A-14
INDIVIDUAL TEST PROFILE SCORES - HEMATOLOGY - TOTAL BLOOD COUNT
GROUP IV

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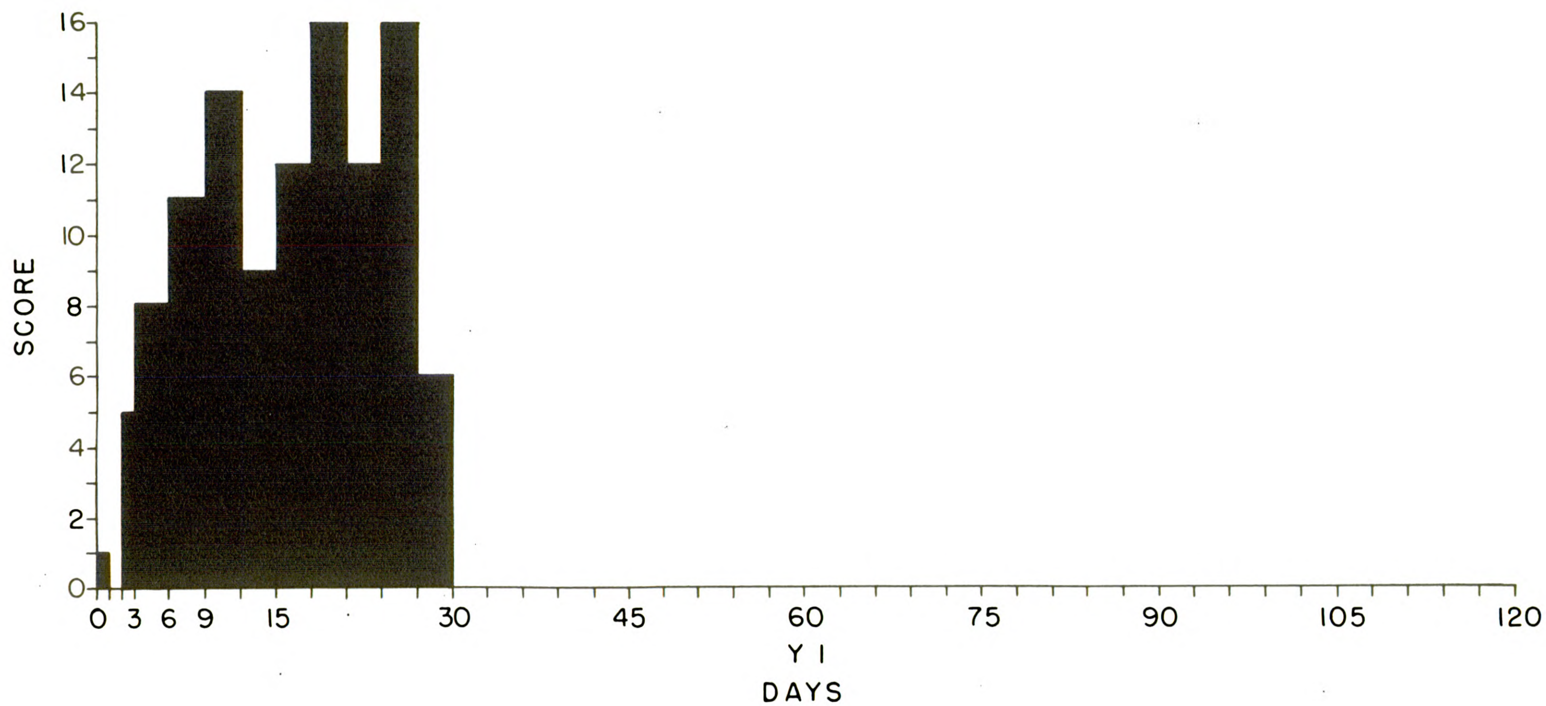

FIG. A-15
INDIVIDUAL TEST PROFILE SCORES – HEMATOLOGY – TOTAL BLOOD COUNT
GROUP IV

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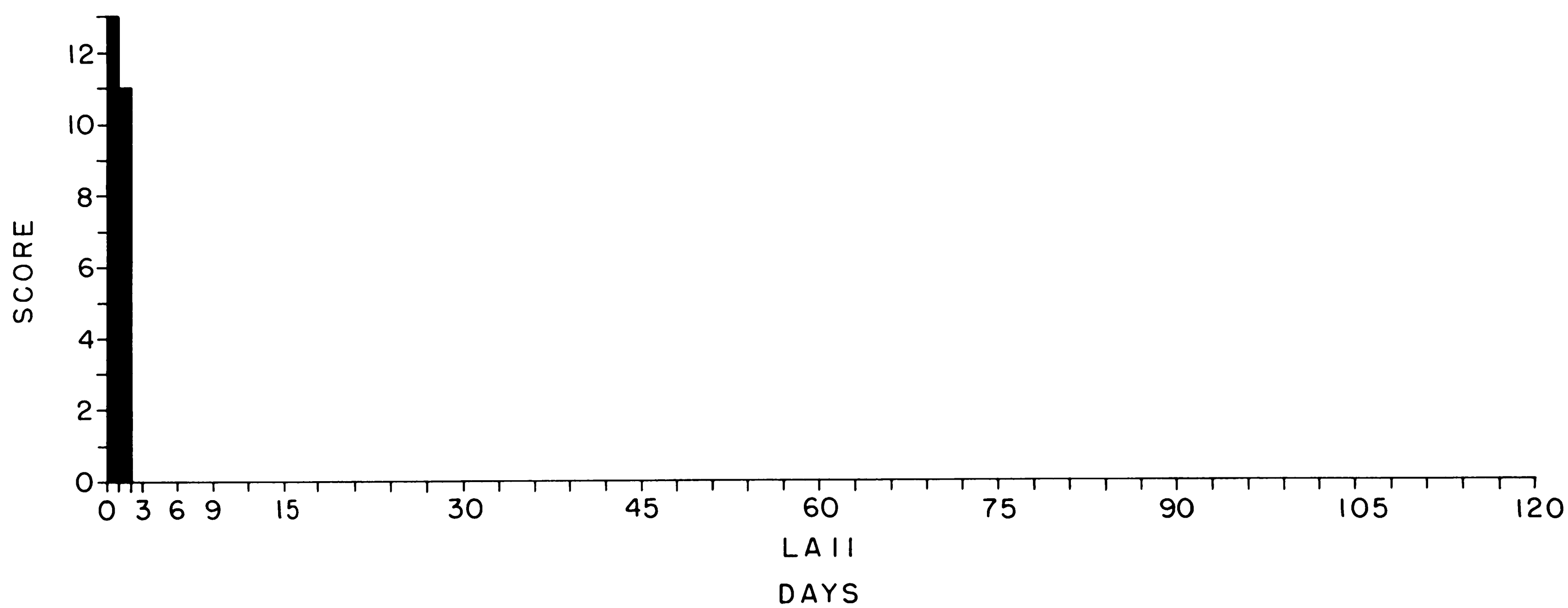

FIG. A-16
INDIVIDUAL TEST PROFILE SCORES-HEMATOLOGY-TOTAL BLOOD COUNT
GROUP V

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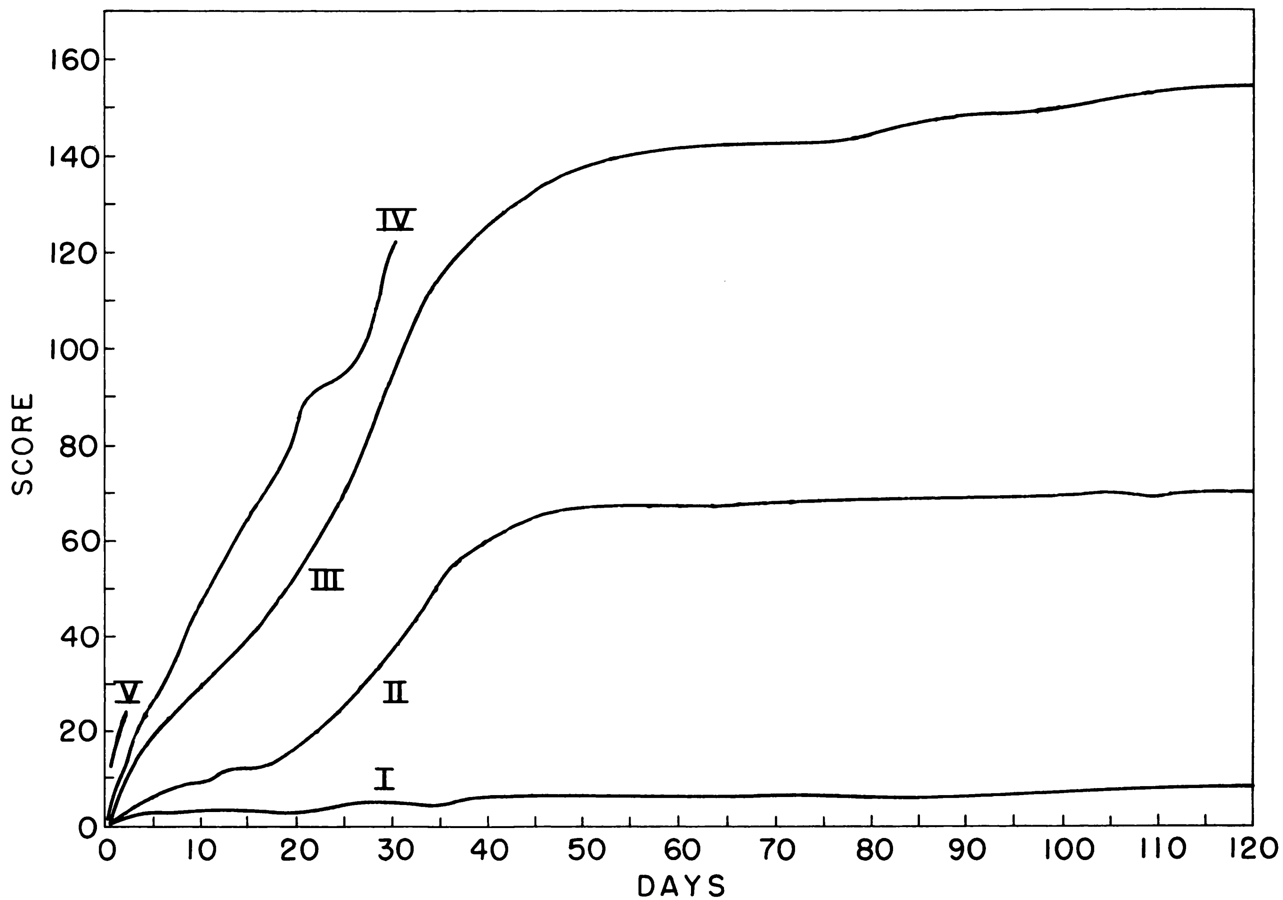

FIG. A-17
GROUP MEAN CUMULATIVE PROFILE SCORES
HEMATOLOGY-TOTAL BLOOD COUNT

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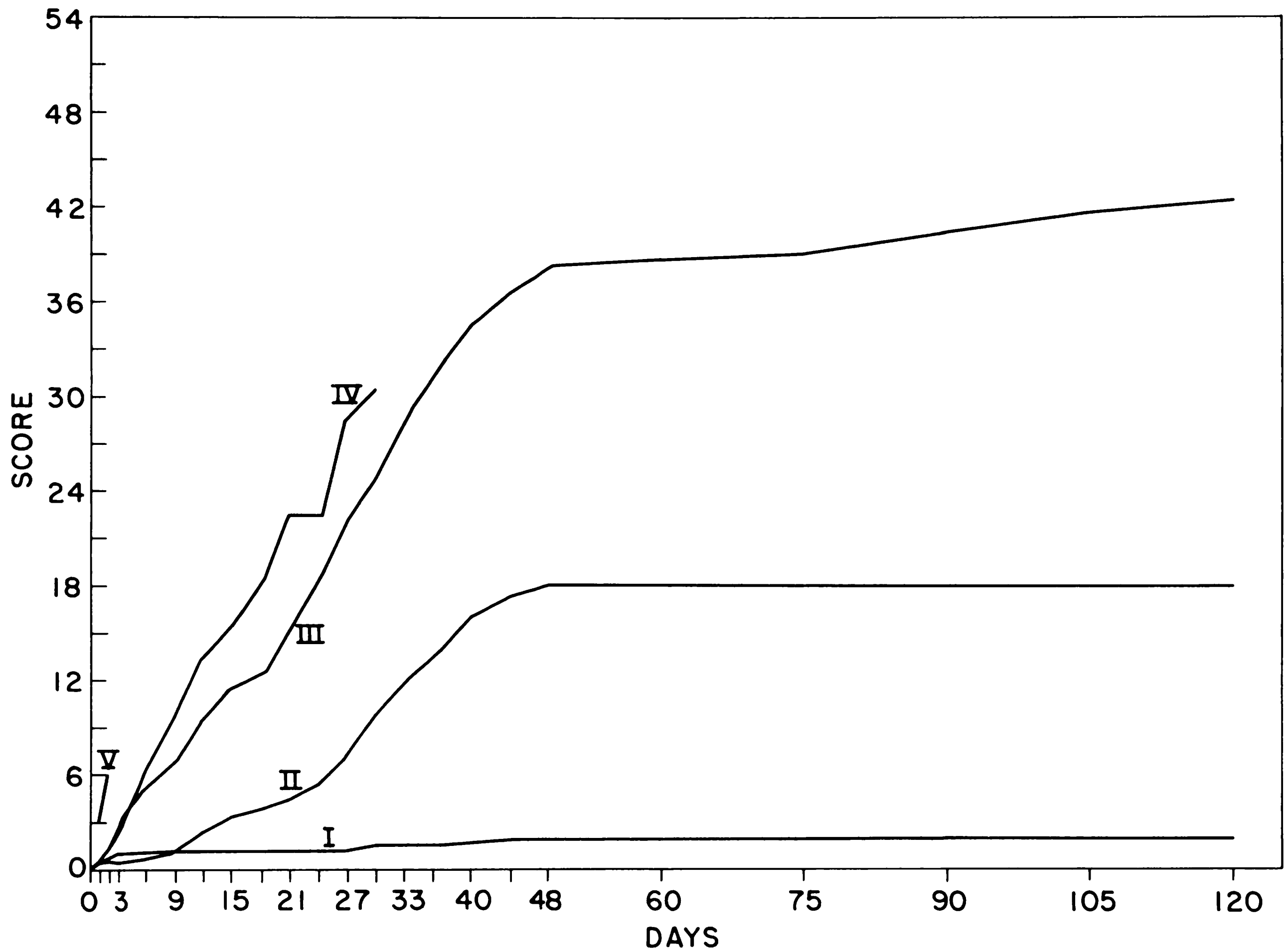

FIG. A-18
GROUP MEAN CUMULATIVE PROFILE SCORES
HEMATOLOGY - LEUCOCYTES

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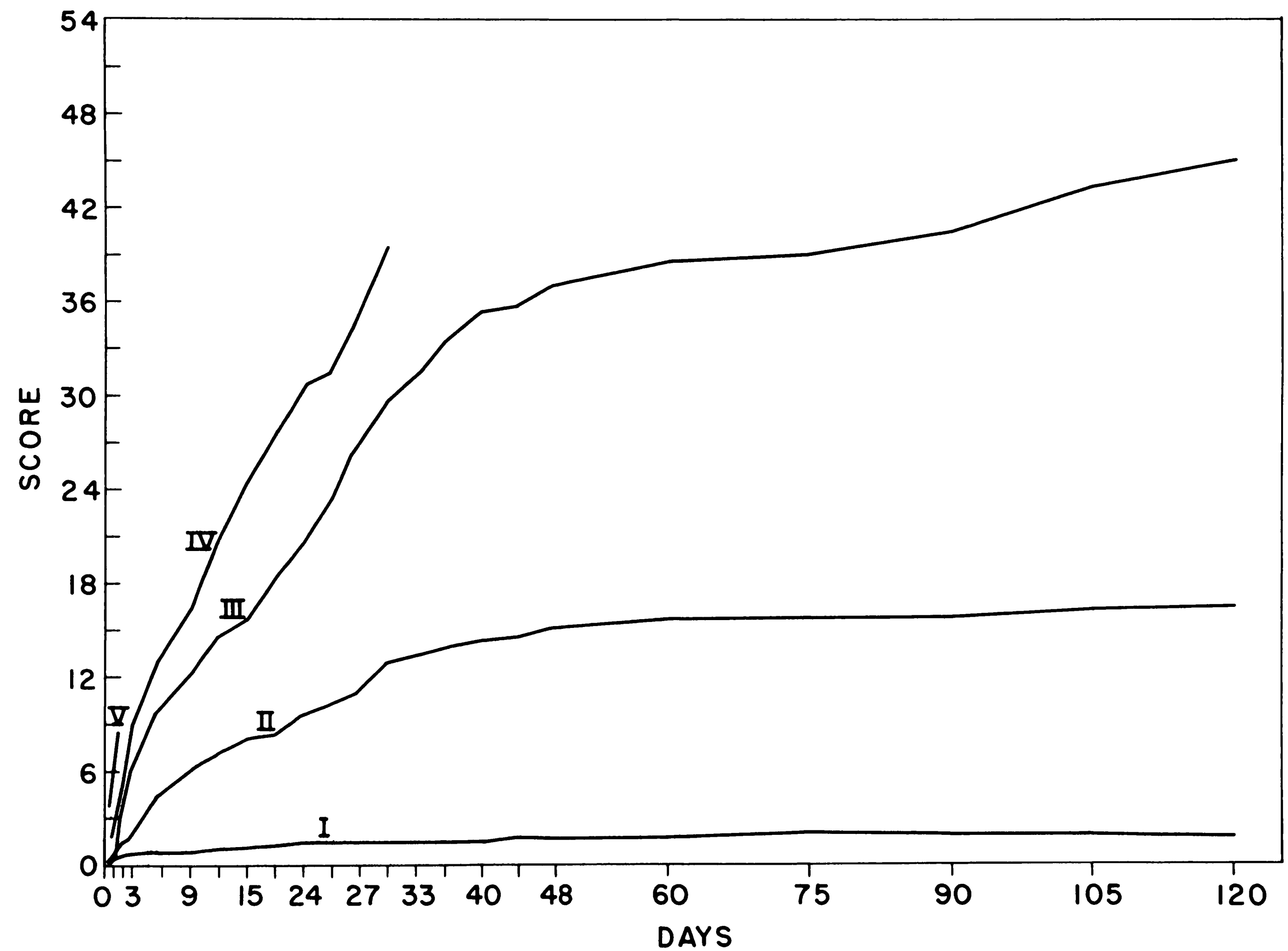

FIG. A-19
GROUP MEAN CUMULATIVE PROFILE SCORES
HEMATOLOGY - LYMPHOCYTES

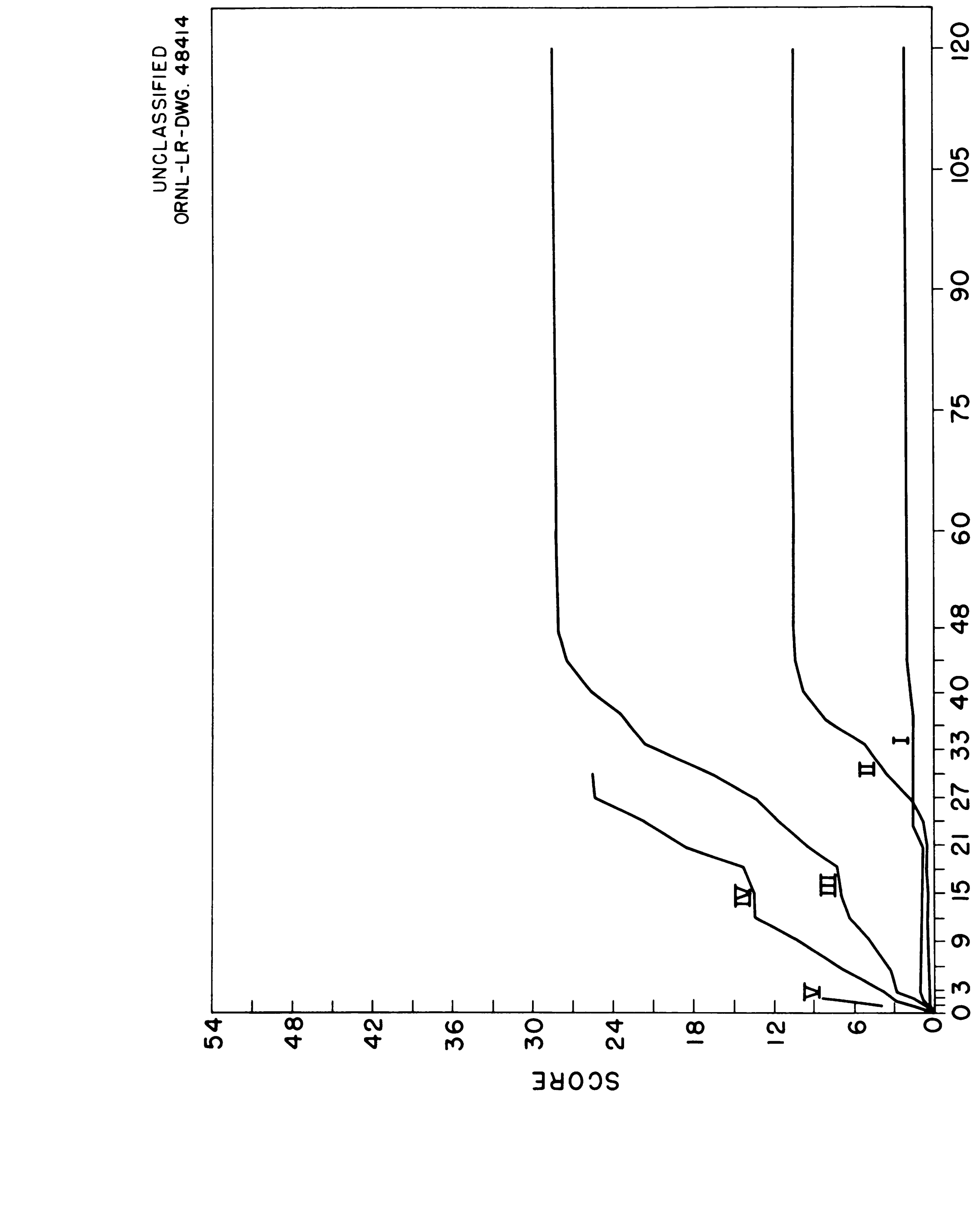

FIG. A-20
GROUP MEAN CUMULATIVE PROFILE SCORES
HEMATOLOGY - NEUTROPHILS

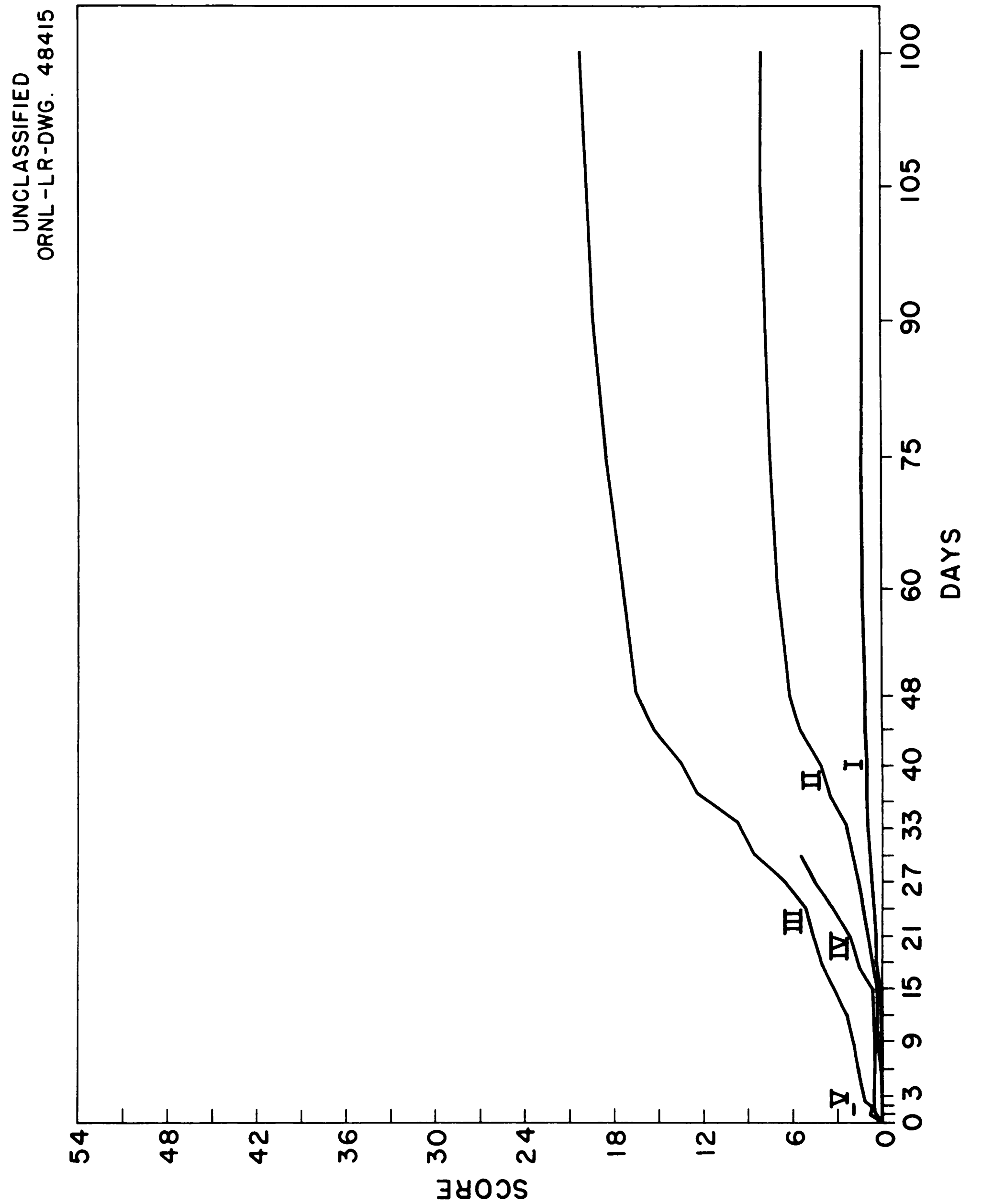

FIG. A-21
GROUP MEAN CUMULATIVE PROFILE SCORES
HEMATOLOGY-ERYTHROCYTES

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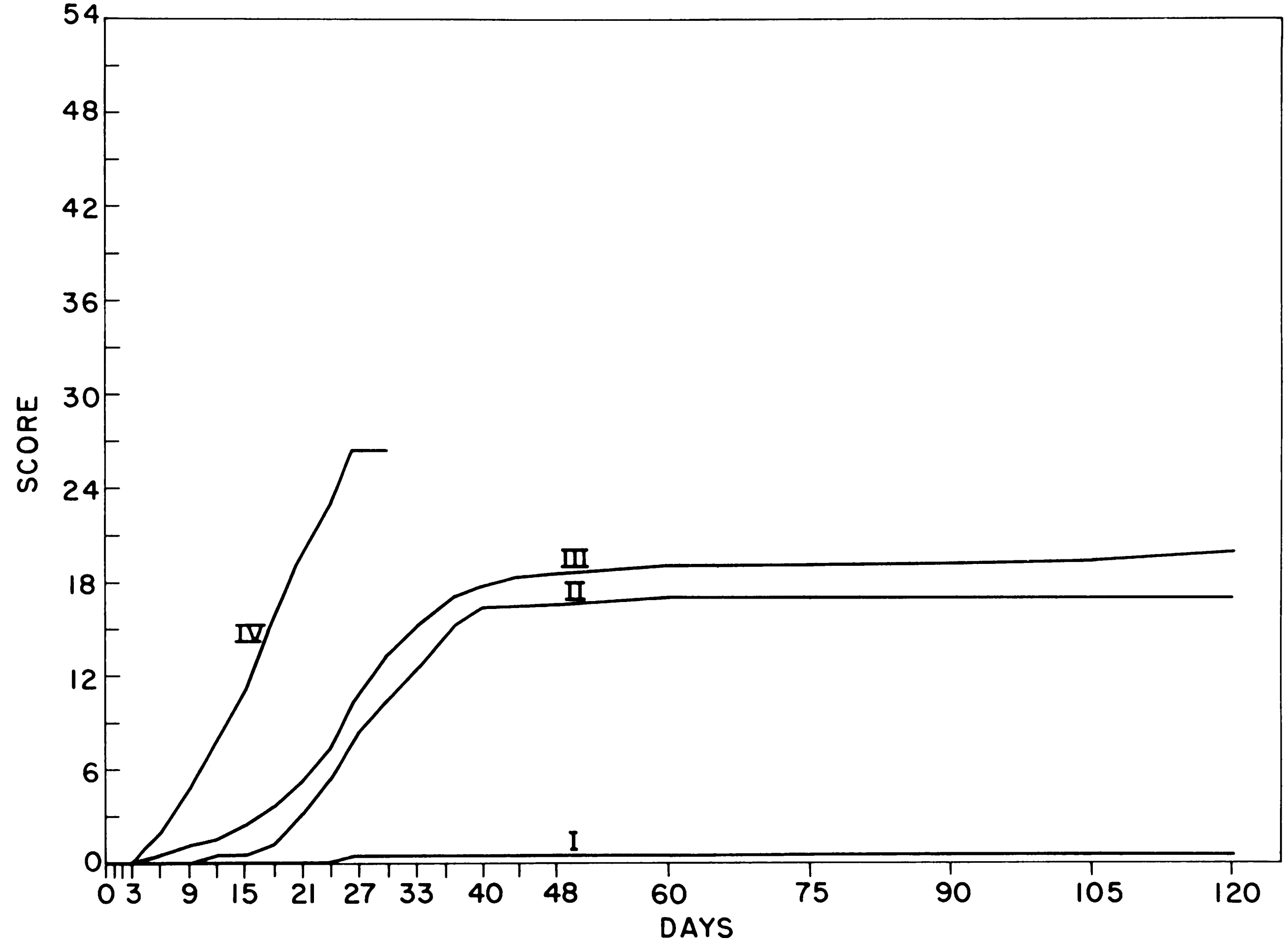

FIG. A-22
GROUP MEAN CUMULATIVE PROFILE SCORES
HEMATOLOGY - PLATELETS

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